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*Final Investigation Report
Blair Backup Property
Port of Tacoma, Washington*

Volume I

*Prepared for
Port of Tacoma*

*January 29, 1992
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**VOLUME VI - PHASE II SOIL AND WATER
LABORATORY AND QUALITY CONTROL REPORTS**

**FINAL INVESTIGATION REPORT
BLAIR BACKUP PROPERTY
PORT OF TACOMA, WASHINGTON**

1.0 EXECUTIVE SUMMARY

The Blair Backup property Final Investigation report summarizes the work conducted to assess the environmental issues associated with the property which may adversely affect human health and the environment given prospective industrial development. This report was completed in accordance with the March 21, 1990, Memorandum of Agreement between the United States Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), the Puyallup Tribe of Indians (Tribe), and the Port of Tacoma (Port). The Memorandum of Agreement guides the environmental investigation and any necessary cleanup of six parcels of property to be conveyed to the Puyallup Tribe pursuant to the Puyallup Tribe of Indians Settlement Act of 1989 and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Blair Backup property is one of these six parcels.

The purpose of this report is to present sampling data gathered in accordance with the Environmental Investigation Work Plans and to provide an evaluation of site conditions including a description of cleanup objectives, if necessary, based on Applicable or Relevant and Appropriate Requirements (ARARs) and health risk characterization as appropriate. This document is provided to the Port, the Tribe, the EPA, and Ecology for review and approval as specified in the Memorandum of Agreement. The Work Plans (Hart Crowser, 1989b and 1990b), and Preliminary Draft (1990c) and Draft Final Investigation Reports (1991c) were reviewed by EPA, Ecology, and the Tribe, and were modified in response to their comments.

The Blair Backup property is approximately 85 acres in area and is located between Taylor Way and Alexander Avenue in the Port of Tacoma, Washington (See Figure 1). The site was divided into four subareas based on past land use and differences in soil and groundwater quality as shown on Figure 2.

- ▶ The **General/Fill Area** occupies the southwestern half of the property, is the largest area, and is currently undeveloped. This area consists of grassland, two areas which seasonally pond, and two fill mounds. This subarea is about 46 acres in area and includes the Reichhold S Ditch, a prominent surface water feature on the northwestern boundary.
- ▶ The **Ohio Ferro-Alloy (OFA)/Pennwalt Area** occupies the eastern property area where the Ohio Ferro-Alloy facility used to operate, and borders on Atochem's (formerly Pennwalt Chemical) Ag-Chem (or Wypenn) area and Taylor Way. This 21-acre subarea also includes a former log storage yard referred to as the Cascade Timber No. 2 Yard. There are two ditches in this subarea — the OFA Ditch and the Pennwalt Ag-Chem Ditch. The outlet of both ditches was blocked preventing surface water discharges from this area at the time of our field investigations.
- ▶ The **North Site Area**, which is also undeveloped, consists mainly of grassland and includes a wetland area. This roughly 11-acre subarea borders on Reichhold Chemical to the west and Taylor Way to the north.
- ▶ The **Alexander Avenue Strip Area** occupies the area between the Reichhold Chemical facilities and Alexander Avenue. This 7-acre subarea is currently undeveloped and Reichhold's groundwater monitoring wells are located on the property.

Many of the findings on the site are discussed relative to these subareas.

1.1 Preliminary Site Assessment

The preliminary site assessment (Hart Crowser, 1989a), similar to an environmental audit, included an historical evaluation of site uses, agency file reviews on both this and adjacent properties, and a site reconnaissance. The findings indicated historical use of the property by a ferrochromium and ferrosilicate manufacturing plant (Ohio Ferro-Alloy), log sorting and storage operations, a small truck repair facility, and a truck washing operation. There were also concerns associated with the adjacent industrial facilities: Kaiser Aluminum and Chemical Corporation; Reichhold Chemical; and Atochem (formerly Pennwalt Chemical). There was known contamination on the Blair Backup

property from Reichhold and Kaiser and there was the potential for other undocumented releases from these adjacent facilities. Figure 3 shows most of the major site features identified during the Preliminary Site Assessment.

1.2 Completed and On-going Remediation

Several remedial actions have been conducted (or are on-going) in accordance with state and federal regulations and as such are assumed to meet state and federal contamination law under the terms of the Memorandum of Agreement between the Port, the Tribe, and Ecology. These include:

- ▶ Remediation activities completed on the property by Reichhold. Reichhold completed contaminated soil removal in Solid Waste Management Unit (SWMU) 49 located in the Alexander Avenue Strip Area of the Blair Backup property under the RCRA Corrective Action program. They have also designed a groundwater remediation system for both the Shallow and Intermediate Aquifers which is planned to include cleanup of contaminated water that has migrated onto the Blair Backup property. The SWMU 49 soil removal was completed (CH2M Hill, 1991a, and EPA and Ecology, 1990). The groundwater remediation systems (pump and treat system for the Intermediate Aquifer and interceptor drain for the Shallow Aquifer) are still in design and performance phases of implementation.
- ▶ Kaiser Aluminum and Chemical Corporation has completed sludge and associated PAH-contaminated soil removal from the Wet Scrubber Sludge Pond area partially located on the Blair Backup property. This removal was conducted under an Ecology MTCA Consent Decree in December 1990 and was approved by Ecology and EPA (Ecology, 1990).
- ▶ The Port removed an underground storage tank located adjacent to the former truck wash and repair facility under a Tacoma-Pierce County Health Department permit dated December 29, 1989. The tank and associated contaminated soil removal was observed and documented by GeoEngineers in March 1990. The results of contamination testing indicated that no further action related to potential subsurface petroleum-related soil contamination was

required (GeoEngineers, 1990). The completion report is presented in Appendix F.

Also on-going is the Port's removal of "nuisance materials" that have been illegally dumped or left on the property. These materials include sandblast waste, drums containing oily materials, small patches of petroleum hydrocarbon stained soils, construction debris, asbestos wallboard and pipe, household waste, and the contents of an on-site septic tank. The work is being conducted by the Port in accordance with the Work Plan for Nuisance Waste (Hart Crowser, 1991b) and consistent with voluntary cleanup provisions of the Model Toxics Control Act, subject to final review by EPA, Ecology, and the Tribe.

1.3 Scope of Work

The sampling and analysis program was designed to address the nature and extent of contamination (if present) on the property to meet the following objectives:

- ▶ Characterize the soil and groundwater conditions;
- ▶ Conduct testing for the possible presence of metals and organic contaminants derived from either historical activities on-site or from migration of contaminants from the adjacent properties; and
- ▶ Assess the risk to human health and the environment based on the collected data to assess the need for remediation on the property.

Data collection for this project was principally completed between December 1989 and April 1991 and consisted of field explorations, chemical analyses, aquifer testing, review of existing documents, and specialized studies related to the project. The field sampling program was generally biased toward areas of suspected contamination, particularly soil sampling. Figures 5, 6, and 7 show the locations of the field explorations. The field program included:

- ▶ 47 test pit explorations (see Figure 6);
- ▶ 26 shallow borings drilled to depths of 9 to 17 feet and 11 intermediate depth borings drilled to 24 to 42 feet (see Figure 5);
- ▶ 79 subsurface soil samples collected and chemically analyzed;
- ▶ 19 surface soil samples collected and chemically analyzed;

- ▶ Charcoal, wood, slag, and ore sample analyses;
- ▶ 11 ditch and sediment samples collected and chemically analyzed (see Figure 7);
- ▶ 4 surface water samples collected and chemically analyzed (see Figure 7);
- ▶ Completion of 32 monitoring wells; 21 shallow wells and 11 intermediate wells;
- ▶ Three rounds of groundwater samples collected and chemically analyzed; 33 samples in January 1990, 13 samples in October 1990 and 37 samples in December 1990;
- ▶ Water level monitoring in January 1990, February 1990, September 1990 and January 1991; and
- ▶ Hydraulic conductivity testing in 22 wells.

The available Reichhold, Atochem, and Kaiser environmental reports were reviewed relative to assessment of potential impacts to the Blair Backup property. Specialized studies were conducted to evaluate local reference concentrations for soil and groundwater in the area of the property. Associated with these local reference studies we reviewed analytical methods for formaldehyde and summarized possible natural sources of iron and manganese (See Volume II Appendices).

1.4 Hydrogeology of the Study Area

Surface Water Features

The Blair Backup property is poorly-drained internally with a few defined ditches along the periphery of the property (see Figure 4). During the wet season water ponds in a large portion of the OFA/Pennwalt and General Fill Areas. The prominent drainage investigated for this study include:

- ▶ The **Reichhold S Ditch** which is by far the largest drainage feature. It begins in the central North Site Area and runs south where it discharges into a deep well-defined ditch which parallels the Reichhold property boundary. The Reichhold S Ditch discharges to the Lincoln Avenue Ditch beyond the Alexander Avenue Strip Area.
- ▶ The **Pennwalt Ag-Chem Ditch** is a well-defined ditch which parallels the western fenceline of the Pennwalt Ag-Chem facility. The

Pennwalt Ag-Chem Ditch no longer has an outflow and water in the ditch either evaporates or infiltrates to the Shallow Aquifer.

- The OFA Ditch occurs in the eastern OFA/Pennwalt Area near the Kaiser property boundary. At one time, this ditch discharged to a piped subsurface drain; however, at the time of our investigation, the drain was clogged with wood debris and there was little or no flow from this ditch. Poor drainage from this ditch is the likely cause for the ponding in the OFA/Pennwalt Area.

Geology and Groundwater Conditions

Recent fill and deltaic/alluvial deposits comprise the geologic units within which the Shallow Aquifer and Intermediate Aquifer occur. Groundwater is recharged on site by precipitation which migrates to the Shallow Aquifer. The Shallow Aquifer is the principal aquifer of concern with regard to water quality issues. Although the Shallow Aquifer recharges the Intermediate Aquifer, there are no water quality concerns of sufficient magnitude to suspect migration of contaminants, if present from the Shallow Aquifer to the deeper Intermediate Aquifer.

A north-south trending groundwater divide occurs within the Shallow Aquifer in the central property area as shown on Figures 12 through 14. In this area the groundwater moves at very slow rates. Groundwater to the east of the divide generally flows toward Taylor Way, and groundwater west of the divide generally flows toward the Reichhold S Ditch at flow rates estimated to be in the range of 0.01 to 0.05 ft/day.

The Shallow Aquifer groundwater discharges to surface water bodies which ultimately discharge to the Blair and Hylebos Waterways. Groundwater which discharges to the Reichhold S Ditch ultimately discharges to the Blair Waterway. Groundwater which flows toward Taylor Way either discharges to backfill materials around the sewer pipe which runs underneath Taylor Way or flows into groundwater beneath the Atochem facility.

Groundwater flows within the backfill around the sewer pipe are likely to follow the route of the drainline if coarse-grained backfill materials were consistently placed around the pipe. The Taylor Way drainline discharges to Lincoln Avenue Ditch north of the property and to the Kaiser Ditch south of the property. These ditches empty into the

Hylebos Waterway. Figure 4 presents the surface water drainage pathways. Groundwater which bypasses the sewer conduit will travel beneath the main Atochem facility before reaching the Hylebos Waterway. Some of this water will likely be captured by Atochem's groundwater extraction system once the system is on line (planned for summer or fall, 1992).

The Shallow and Intermediate Aquifers are not considered suitable for water supply because of limited yield and/or poor water quality. Under MTCA, the groundwater data for this property were screened relative to marine water quality levels because the groundwater ultimately discharges to marine surface waters.

1.5 Soil, Ditch Sediment, and Water Quality Concerns

Screening Criteria

Soil, ditch sediment, and water quality data were screened relative to Model Toxic Control Act (MTCA) cleanup levels (173-340 WAC). MTCA cleanup levels were selected for screening because they are conservative and they incorporate other ARARs. For soils we compared the data to MTCA Methods A and C industrial soil cleanup levels (See Table 7) because the site is currently zoned industrial, surrounding site use is industrial, and the future use plans are to remain industrial under the Tribe/Port of Tacoma Implementing Agreement. Sediment quality data from on-site ditches were compared to the MTCA industrial soil cleanup levels, if they are wholly contained inland, or state marine sediment quality levels if they discharge to the marine waterways.

Groundwater quality data were compared to MTCA marine surface water quality cleanup levels (See Tables 8 and 16) because the aquifers are not usable for drinking water because of limited yield, poor natural water quality, or both. Under MTCA, if groundwater meets these criteria and is unlikely to ever be used as a drinking water source, the cleanup level may be based on protecting beneficial use of adjacent surface water bodies. The MTCA marine surface water quality levels are conservative screening levels for site groundwaters because these levels are applicable at the point of groundwater discharge to a surface water body and there is considerable distance (over 1,000 feet) between

the site groundwater, the site boundaries, and the Hylebos and Blair Waterways.

We also reviewed site soil data relative to regional background soil data and Port of Tacoma local reference soil concentrations (Tables D-1 and D-3). Soil and sediment data were compared to local reference concentrations established for this project, Puget Sound background soil data (Harper Owes, 1985 and Dexter et al., 1981), and the western U.S. regional soil data (Shacklette and Boerngen, 1984). Surface water and groundwater data were compared to local groundwater reference concentrations established for this project (Appendix D), Puyallup River water quality (Ebbert et al., 1986), and residential stormwater quality (Metro, 1982).

The following discussions present the issues identified based on the screening of the soil, sediment, and water quality data relative to the MTCA cleanup levels and area background and local reference values.

Soil and Sediment Quality

Elevated Arsenic in Reichhold S Ditch Sediment. Total arsenic levels in the Reichhold S Ditch exceeded the state marine sediment quality criteria (57 mg/kg) in four of the samples analyzed and the MTCA Method A industrial soil level (200 mg/kg) in two samples. Arsenic concentrations in the Reichhold S Ditch sediments ranged from 23 to 400 mg/kg range. The ditch sediment sampling locations are shown on Figure 7.

The arsenic may be related to Asarco slag which has been found in fill on the Blair Backup property (OFA/Pennwalt Area) and the northeastern portion of the Reichhold facility. It is also possibly related to sandblast grit found in the North Site Area near the drainage ditch which divides the North Site and OFA/Pennwalt Areas. This drainage ditch discharges to the Reichhold S Ditch. The surface water drainage pathway for Asarco slag particulates from the OFA/Pennwalt Area to the Reichhold S Ditch no longer exists. The sandblast grit is being removed as part of the Nuisance Material cleanup action.

Although, the Reichhold S Ditch drains to the Lincoln Avenue Ditch and ultimately to the Blair Waterway, it is unlikely that sediment in the ditch will impact the Blair Waterway. The most likely transport

pathway is as suspended material in the surface water. Average total arsenic concentrations measured in surface water samples taken from the Reichhold S Ditch were within the Port area reference level of 5 ug/L. Dilution and dispersion in the Lincoln Ditch which receives the Reichhold S Ditch waters will further decrease this concentration before discharge to the Blair Waterway.

Mercury and PAH in North Site Area Soil. Mercury was detected in two soil samples but only one sample (TP-116/S-2 at 2 mg/kg) exceeded the 1 mg/kg MTCA Method A industrial soil cleanup level. PAHs were also detected in this area, but were not detected at levels above the MTCA Method A industrial soil cleanup level.

The source of these constituents may be related to some unknown activity close to this area since both of these constituents are generally low in mobility. The occurrence may be related to undocumented reports of equipment storage or unknown Reichhold discharges near this area. Some of the PAHs may be naturally occurring because of peaty soils (Callahan et al., 1979). Due to the low mobility of mercury and PAHs in groundwater and the distance from the waterways, substantial impacts to surface water or groundwater quality are unlikely.

Elevated Metals and PAHs in OFA/Pennwalt Area Soil. Arsenic, chromium, cadmium, mercury, and lead were detected at levels which exceeded MTCA industrial soil cleanup levels in the OFA/Pennwalt Area (See Figures 18 and 19). Only arsenic and chromium exceeded the MTCA cleanup level in more than one sample. Because cadmium, mercury, and lead exceeded the MTCA industrial soil cleanup level at only one location (one sample out of 31 samples analyzed) they are not considered to be a substantial concern. The elevated metal concentrations occur within the slag fill area, which occupies most of the east central OFA/Pennwalt Area. Most of the slag fill is OFA slag and ore; however, Asarco slag is scattered throughout the area. It is likely that arsenic is related to the Asarco slag and chromium is related to the OFA slag.

Five samples of the slag fill were tested for metal leachability using the toxicity characteristic leaching procedure (TCLP) test and seven samples were analyzed for extraction procedure toxicity (EP Tox). None of the samples exceeded dangerous waste designation levels. In fact, arsenic, barium, copper, lead, and zinc were the only metals detected in the

leachate and the arsenic was detected in only one of the 13 slag fill samples analyzed for EP Tox or TCLP metals. The arsenic was detected in a sample which contained Asarco slag. The low leachability of metals from the OFA slag is consistent with the generally low concentration of metals found in groundwater from wells completed in the OFA slag fill area.

PAHs were also found to exceed the MTCA Method A and Method C industrial soil cleanup levels in the OFA/Pennwalt Area. The exceedences were primarily related to a half-acre area that contained charcoal briquets. The remaining PAHs were related to a timber with a creosote-like odor and related construction debris.

Arsenic in OFA Ditch Sediment. Arsenic was detected in two discrete ditch sediment samples at concentrations (260 mg/kg) that slightly exceed the MTCA industrial soil cleanup level (200 mg/kg). Composite ditch sediment samples did not exceed the MTCA cleanup levels. The discrete sediment samples were obtained near a road overpass that appeared to have used some of the local slag for construction. It is likely these sediment results reflect particles of Asarco slag.

Surface Water Quality

Elevated Arsenic in OFA Ditch Water. Arsenic was consistently detected in the three OFA Ditch surface water samples above the MTCA marine water cleanup level, the residential stormwater quality data, and the Puyallup River water quality data. The highest concentrations were observed during the wet season when flow was blocked in the ditch backing up water throughout the slag fill area. Elevated concentrations of cadmium, copper, lead, nickel, and zinc were also detected in the wet season sample probably due to an increase in surface water contact time, and increased surface water area covering the slag fill.

Nickel and Zinc in Reichhold S Ditch Water. Data collected by Reichhold in 1989 indicated nickel, zinc, arsenic, and copper concentrations exceed the MTCA marine surface water quality levels (CH2M Hill, 1989a). However, nickel and zinc were the only priority pollutant metals which exceeded both MTCA marine surface water cleanup levels and reference conditions as defined by residential stormwater runoff data and Puyallup River water quality data (See

Table 20). Surface water in the Reichhold S Ditch discharges to the Lincoln Avenue Ditch prior to discharging to the Blair Waterway. Nickel and zinc have not been identified as being of concern in the sediments or surface waters of the Lincoln Avenue Ditch (Landau, 1991).

Groundwater Quality

Nickel and Zinc in General/Fill Area Groundwater. Nickel and zinc concentrations are elevated in the Shallow Aquifer groundwater in the General/Fill Area. The highest concentrations occur in the central area around HC-13S and HC-2S (average nickel at 490 and 455 ug/L and average zinc at 300 and 455 ug/L, respectively). The source of these metals is unknown but may be related to sandblast waste, other unknown metallic wastes in the less explored areas of the fill, or selective leaching of natural soil by low pH groundwater found in this area. The nickel and zinc concentrations drop off significantly as the groundwater moves toward the Reichhold S Ditch. Average nickel and zinc level in downgradient wells HC-1S and HC-3S located near the ditch were at least 2 to 10 times lower than those in wells HC-13S and HC-2S.

Metals and PAHs in OFA/Pennwalt Area Groundwater. Arsenic, chromium, copper, and nickel were the principal metals which exceeded the MTCA marine surface water levels in Shallow Aquifer groundwater in the OFA/Pennwalt area. As shown on Figure 22, the highest metal concentrations are observed around the Pennwalt Ag-Chem facility (EPA-9S, HC-4S, and HC-5S) and near Taylor Way (HC-6S) and not in the slag fill. Arsenic is the only metal which exceeds both the MTCA marine surface water levels and the local reference concentrations (as defined by this study) based on average concentrations (see Table 20).

Occurrence of the elevated metal concentrations around the Pennwalt Ag-Chem fenceline area coincides with an area of high pH groundwater. The high pH groundwater is probably related to leakage from above-ground storage tanks on the Ag-Chem property which contained sodium hydroxide. The higher dissolved metals around the Ag-Chem fenceline may be due to selective leaching of the soils by the higher pH waters.

The dissolved metals in the groundwater will migrate toward Taylor Way. These groundwaters will either discharge to the backfill around the sewer line beneath Taylor Way or migrate beneath the Atochem facility. If the groundwater discharges to the backfill it could be diluted by other groundwaters by as much as ten-fold reducing concentrations to below marine chronic standards (40 ug/L for arsenic). If it flows beneath the Atochem facility it will likely be captured by their groundwater extraction system planned for initial operation in the summer or fall of 1992. Considering the likelihood of geochemical reactions reducing the metal concentration and the effects of dispersion, the metal concentrations should be reduced to below the marine water quality criteria prior to entering the Hylebos Waterway.

PAHs were also detected at elevated concentrations in both the Shallow and Intermediate Aquifers groundwater in the OFA/Pennwalt Area above the MTCA cleanup levels. These constituents are probably related to suspended sediment in the water sample as PAHs are generally not water soluble. The PAH levels in the intermediate wells, HC-4I and EPA-8I, may be related to carry down of sediment from soils within the Shallow Aquifer during drilling, although efforts were made to minimize this possibility in HC-4I. We would not expect any significant migration of these constituents and have not detected PAHs in wells downgradient.

Vinyl Chloride in North Site Area Groundwater. Vinyl chloride was detected in the Shallow Aquifer throughout the North Site Area at concentrations ranging from 5 to 85 ug/L (36 ug/L average). These measured concentrations exceed the MTCA marine surface water cleanup level of 3.4 ug/L in all of the samples. However, the vinyl chloride concentrations decreased by between 50 and 80 percent between the first and the second sampling round and based on the volatile nature of this compound it is likely to continue to degrade. This chemical would be further attenuated through dilution and volatilization during transport to the waterways to levels which are unlikely to cause significant environmental or human health impacts.

The source of the vinyl chloride may be related to a past release from Reichhold's former septic system or the past use of the area for storage and cleaning of vehicles. Low levels (below cleanup levels) are found in soils in the North Site Area. Vinyl chloride is a breakdown product of the common industrial solvents — tetra- and trichloroethylene.

Formaldehyde in Groundwater. Formaldehyde was detected in groundwater throughout the property. The highest concentration we detected was 260 ug/L in HC-13S. However, only 4 samples exceeded the Port of Tacoma local reference concentration (range of <5 to 60 ug/L).

There are no known sources of formaldehyde on the property. Reichhold has used it in the past but migration appears unlikely because the Reichhold S Ditch intercepts most of the shallow groundwater flow toward the property in the western area where Reichhold detected formaldehyde in the groundwater. Our highest concentrations were detected in the central and northern portions of the property. It is believed that these concentrations are either derived from a natural or regional sources of formaldehyde or are due to analytical interferences which result in quantifying other compounds as formaldehyde. See Appendix J for more discussion on formaldehyde.

1.6 Risk Evaluation

A risk evaluation was conducted to assess the potential for soil and water quality concerns to impact human health and the environment. The risk assessment evaluates potentially exposed populations and exposure pathways for chemicals detected in soil, sediment, and groundwater which exceeded MTCA cleanup levels. The analysis considered both current site use and future industrial use. The risk evaluation focused on human health impacts; however, the MTCA criteria used to screen the data also represent potential impacts to the environment.

The risk assessment was conducted using generally health-conservative assumptions that tend to overestimate the risk and as such generally represents a health risk that is a maximum relative to actual exposures. It should not be construed to represent an absolute estimate of potential risk to human health. Rather, it is intended to indicate the potential for adverse impact to occur.

A potential excess cancer risk of 10^{-5} was considered to be the threshold value for determining the need for remedial alternative analysis for the Blair Backup property. This is based on MTCA which considers 10^{-5} as the threshold risk for industrial site use. EPA considers 10^{-4} to 10^{-6} as the appropriate target range for remedial action. For non-carcinogens,

a Hazard Index of less than 1 meets Ecology MTCA and EPA CERCLA guidelines (see Tables 27 and 28).

For current site use the identified and evaluated pathways for exposure include:

- ▶ Inhalation by off-site workers of fugitive dusts released from surface soil; and
- ▶ Inhalation by off-site workers of vapors emitted from on-site groundwaters.

Future-use exposure pathways identified and evaluated include:

- ▶ Dermal contact with and incidental ingestion of soil by on-site workers;
- ▶ Inhalation by on-site workers of fugitive dusts emitted from site soils;
- ▶ Inhalation by on-site workers of vapors released from surface soils; and
- ▶ Dermal contact and incidental ingestion of on-site sediments.

The current site use meets both the EPA and MTCA target risks. The estimated potential excess cancer risks for current site use (10^{-7} to 10^{-9}) were below the threshold risk of 10^{-5} and the Hazard Index for current site use was less than one. In addition, multipathway exposures were well below EPA and MTCA target risks for current site use.

Future industrial use at the site exceeded the threshold risk of 10^{-5} for average exposure conditions only in the case of direct contact by workers with charcoal-laden soils (cPAHs) in the OFA/Pennwalt Area. When the charcoal is removed, which is planned, no other exposures exceed the target risk under the average exposure scenario. However, future risks under the maximum exposure case (RME) indicate minor exceedences of the target risk for the following exposures:

- ▶ Inhalation of vapors emitted from groundwater in the North Site Area (RME risk 2×10^{-5}),
- ▶ Inhalation of dust generated from soils containing chromium in the OFA/Pennwalt slag-fill area (RME risk 2×10^{-5}),

- ▶ Direct contact with soil and sediment containing arsenic in the OFA/Pennwalt slag-fill area (RME risk between 2×10^{-5} and 3×10^{-5}).

The maximum or RME exposure scenario considers a worker is exposed to soil over arms, legs, and hands for a duration of 25 years under a normal work week. This is a potentially accurate condition if daily earthwork is part of the future use and protective clothing is not worn. The federal OSHA regulation requires protective clothing during construction activities.

1.7 Conclusions and Recommendations

While a number of constituents in various media exceed the screening criteria, relatively few pose a risk to human health and the environment. The human health risks of concern relate to future site use which includes daily soil contact of an industrial worker. The primary risk relates to charcoal (source of cPAHs) which is already planned for removal. Lesser risks were identified for inhalation of slag dust containing chromium and direct contact with slag-laden soils containing arsenic and PAH compounds. Potential environmental impacts include the release of metals to surface water bodies through off-site transport of sediment and surface waters from the OFA/Pennwalt Area and General/Fill Area.

We recommend that the alternatives analysis address the identified soil and water quality concerns. Based on the assessment of the potential for human health and environmental impacts we believe that commercial or industrial development of the property is feasible given that the following concerns are addressed:

- ▶ The charcoal and related soils are removed. This will eliminate the primary PAH source in the OFA/Pennwalt area.
- ▶ Controls are instituted to minimize contact with the slag fill in the OFA/Pennwalt Area. This could include a fill cover or institutional controls which restrict site uses that allow daily contact with the slag fill.
- ▶ The potential for the airborne transport of dust from the OFA/Pennwalt slag fill area is controlled.

- ▶ Surface water runoff from the site is controlled to reduce contact time with the slag and minimize the transport of slag particulates in surface water discharges from the site. We also recommend additional surface water sampling in the OFA Ditch to verify our hypothesis that the arsenic observed in the ditch water is primarily related to suspended sediment.
- ▶ Groundwater monitoring is conducted in the North Site Area to confirm that natural degradation of the vinyl chloride detected in groundwater in this area will reduce volatilization risks to below acceptable levels.
- ▶ The suspected attenuation of nickel and zinc levels in the Reichhold S Ditch is confirmed through metals loading and attenuation analysis.

Institutional controls may be required for subareas of the property depending on the remedial options selected. Institutional controls include restrictions on property use such as prohibition on use of groundwater for drinking purposes. The need for institutional controls will be evaluated in the remedial alternatives analyses.

2.0 Introduction

2.0 INTRODUCTION

2.1 Purpose and Context of This Report

This Blair Backup property Final Investigation report was prepared for the Port of Tacoma by Hart Crowser, Inc. The purpose of our work was to identify environmental issues associated with the Blair Backup property which may adversely affect human health and the environment given prospective industrial development of the property.

This report was completed in accordance with the March 21, 1990, Memorandum of Agreement between EPA, the Washington State Department of Ecology (Ecology), the Puyallup Tribe of Indians (Tribe), and the Port of Tacoma (Port) and supersedes previous investigation reports on the Blair Backup property. The Memorandum of Agreement guides the environmental assessment and necessary cleanup of six parcels of property to be conveyed to the Puyallup Tribe pursuant to the Puyallup Tribe of Indians Settlement Act of 1989 and state and federal contamination law. The Blair Backup is one of six parcels. This document is provided to the Port, the Tribe, EPA, and Ecology for review and approval as specified in the Memorandum of Agreement.

Other studies conducted by Hart Crowser which are covered under the Memorandum of Agreement include the Taylor Way property and East-West Road property environmental assessments. The three properties are shown on Figure 1. Additional properties involved in the Port-Tribe agreement are covered in reports prepared by Landau Associates, Inc.

2.2 Site Location and Description

The Blair Backup property includes approximately 85 acres of land between Taylor Way and Alexander Avenue in the Tacoma tideflats area (Figure 1). The site is bounded by the Reichhold Chemical facility to the west, Alexander Avenue to the south, the Kaiser Aluminum and Chemical facility to the east, and the Atochem (formerly Pennwalt Chemical) facility to the north. The property is X-shaped and relatively flat, except in several localized areas where fill materials have been piled forming small plateaus. The Port of Tacoma installed a fence along the property boundaries in the summer of 1990.

We have divided the site into four subareas as shown on Figure 2. These areas were delineated based largely on past land use and differences in soil and groundwater quality across the property. These include:

- ▶ **The General/Fill Area.** This is the largest area and currently is undeveloped. This portion of the site consists mainly of grassland with several seasonal ponds and two localized areas where fill has been mounded forming small plateau-like features. It is approximately 46 acres in area.
- ▶ **The North Site Area.** This 11-acre area is also undeveloped and consists mainly of grasslands and includes an approximately 5-acre wetland.
- ▶ **The Alexander Avenue Strip Area.** This area is a narrow strip of property located between the Reichhold facility and Alexander Avenue. It occupies about 7 acres of the Blair Backup property. Reichhold established three waste disposal areas (SWMU 33, 44, and 49) in the Alexander Avenue Strip Area in the 1960s and 1970s, and has installed a portion of their groundwater extraction system in this area.
- ▶ **The Ohio Ferro-Alloy (OFA)/Pennwalt Area.** This area is currently unused, is fairly flat, and often floods during the wet season due to poor drainage. The area was formerly used for the Ohio Ferro-Alloy chromium and ferrosilicate manufacturing plant and for a log sorting and storage area (Cascade Timber No. 2). This area covers about 21 acres of the property.

Several buildings and a large parking area leased by the Puyallup Tribe are located in the northwestern portion of the Ohio Ferro-Alloy (OFA)/Pennwalt Area. One of those buildings (2902 Taylor Way) was formerly used by Pennwalt as an experimental laboratory for research involving solid rocket fuels. A vehicle steam cleaning facility was also operated out of a building located south of the former Pennwalt laboratory building.

2.3 Property Zoning

The Blair Backup property is zoned as M-3 Heavy Industrial which permits most heavy industrial uses. This zoning prohibits the construction of residential dwellings on the property. In addition, the Puyallup Settlement Agreement precludes use of the property for residential purposes.

2.4 Project Background

The project began with a preliminary site assessment that included an historical characterization of the Blair Backup property, an agency file review, and a site reconnaissance. The findings were presented in our Phase I Environmental Audit report (Hart Crowser, 1989a). The principal findings from the historical site use assessment included:

- ▶ Ohio Ferro-Alloy Corporation (now called Simetco) operated the major industrial facility on the site. The facility was a chromium and ferrosilicate manufacturing plant, which occupied approximately 15 acres in the eastern portion of the site. The facility was built in 1941 and remained until 1974. Additional information on this facility is provided in Appendix I.
- ▶ Log sorting yards have periodically occupied the site since 1974. Some Asarco slag has been found on the site, which may have been introduced by log sorting operations. However, a limited site assessment on the former Cascade Number 2 log sorting yard (located on the former OFA site) concluded that Asarco slag was not present in large enough quantities to indicate that it was used as ballast material (Hart Crowser, 1986b). Ecology and Environment (1987) also conducted a site assessment on the former Cascade Number 2 site. Their data indicated that there may be a groundwater quality concern at the site due to the presence of metals and polynuclear aromatic hydrocarbons (PAHs).
- ▶ Commercial operations were active on the northern portion of the site (approximately 25 to 30 acres) for about 15 years. These operations included a truck repair shop and a vehicle steam cleaning facility which was closed in 1990.

- ▶ Adjacent land uses include three industrial facilities: Kaiser Aluminum & Chemical, Reichhold Chemical, and Atochem.

Based on the former site uses and our site reconnaissance of current site conditions, there was potential for on-site soil, sediment, and groundwater contamination related to:

- ▶ Solid and liquid waste from Ohio Ferro-Alloy (OFA);
- ▶ Asarco and OFA slag mixed with wood waste;
- ▶ Oily chemical wastes and some oil-stained soil from former truck repair and steam cleaning operations; and
- ▶ Recent soil and debris disposal on the property including household trash, sandblast waste, and construction debris. Several drums of oily waste material and localized patches of hydrocarbon-stained soil were also observed. A subsurface structure identified as a septic tank with residual sludge was encountered during the course of our explorations (see Figure 3).

Additionally, there was either known, or the potential for, soil and groundwater contamination on site related to activities on the adjacent facilities. Particular concerns were:

- ▶ Known chemical releases on and around the Reichhold Chemical facility which have resulted in soil and groundwater contamination;
- ▶ Infiltration of wastewater and deposition of sludge materials from Kaiser wet scrubbers; and
- ▶ Potential for soil and/or groundwater contamination from former activities at the Atochem facility, particularly the former Wypenn or Ag-Chem facility directly adjacent the OFA portion of the property.

Our review of regulatory agency files indicated that while there was little information related to on-site activities; however, the information related to adjacent industrial activities was plentiful. In particular, numerous spills and permitted discharges were documented. Atochem, Kaiser, and Reichhold are at various stages of conducting site assessment and remediation of contaminated soils and groundwater

under State of Washington or EPA administrative actions. In the case of Kaiser and Reichhold, remedial action has and/or will take place on the Blair Backup property as discussed below.

Our investigation Work Plan (Hart Crowser, 1989b) was designed to address the specific issues identified in the Preliminary Site Assessment. Therefore, our investigation of site conditions was focused in specific areas of concern. This is reflected in our exploration locations, which are clustered in or near areas of concern, and in our chemical testing, which is often related to a particular suite of constituents associated with an area of concern. Our exploration and testing program does, for reference, provide some coverage of areas not identified as of concern during the preliminary site assessment.

2.5 Completed and Ongoing Remediation Efforts

Several remediation efforts have been completed or are in progress on and around the site. These are briefly described below.

Reichhold is currently implementing an interim corrective action program under RCRA. All planned remedial activities under RCRA have been completed except for groundwater remediation. The interim corrective actions proposed and/or completed by Reichhold (CH2M Hill, 1988a) include the following:

- ▶ A shallow interceptor drain has been installed around the perimeter of the Reichhold Plant site. This drain is designed to collect contaminated groundwater in the Shallow Aquifer and divert it to an on-site treatment system. Some cleanup of the shallow groundwater on the Blair Backup Alexander Avenue Strip Area will be accomplished with this interceptor system.
- ▶ An Intermediate Aquifer groundwater extraction and collection system has been installed on the Reichhold Plant site and on the Blair Waterway property. This system is designed to remove and treat contaminated groundwater from the Intermediate Aquifer on the Reichhold Property and portions of the Blair Backup and Blair Waterway properties.
- ▶ A water treatment system has been installed which will accept groundwater from the Shallow Aquifer interceptor trench and the

Intermediate Aquifer extraction system. The wastewater treatment process uses a combination of chemical (H_2O_2) and ultraviolet oxidation. The process also includes iron flocculation and precipitation steps.

- ▶ A site cap and surface water drainage system have been installed on portions of the Reichhold property. The site cap consists of asphalt, concrete and gravel and is intended to minimize human contact and infiltration of penta-contaminated soils.
- ▶ Contaminated soils from solid waste management unit 49 have been excavated and disposed of in engineered waste piles on Reichhold's property to be eventually treated on-site. The SWMU 49 removal is complete (CH2M Hill, 1991a and EPA and Ecology, 1991).
- ▶ Other Reichhold solid waste management units on the Blair Backup property (33 and 44) were sampled and tested (CH2M Hill, 1989d) for organic and inorganic constituents. The data presented by CH2M Hill indicate that soil concentrations of the constituents detected do not require RCRA corrective action.
- ▶ Precorrective action groundwater monitoring is being performed on a quarterly basis. Although the groundwater pump and treat systems are not yet in full operation, some groundwater is being pumped from the shallow interceptor drain and the intermediate aquifer extraction wells on an intermittent basis.

Kaiser Aluminum and Chemical Corporation has removed PAH-contaminated soils and sludge from the Wet Scrubber Sludge Area which extended onto the Blair Backup property under a MTCA Consent Decree. This remedial action was largely completed in December 1990 (Landau, 1990) and approved by Ecology (Ecology, 1990). In addition, the Port has removed the underground storage tank (UST) from the Taylor Way side of the Blair Backup property. This work, which was conducted in early 1990, is documented by GeoEngineers (1990) and conducted under approval of the Tacoma-Pierce County Health Department. The report is provided in Appendix F.

The Port is currently cleaning up the "nuisance materials" that have been disposed of on the Blair Backup property. A Work Plan for

removal of the Nuisance Materials has been prepared (Hart Crowser, 1991b). These actions are being completed as a voluntary cleanup under MTCA and will be subject to the approval of EPA, Ecology and the Tribe. They include:

- ▶ **Sandblast Grit.** The material is being excavated, stockpiled, and tested for disposal designation. The area of excavation is being tested to confirm complete removal. The sandblast grit will be removed from the site and properly disposed.
- ▶ **Drums Containing Oily Wastes.** The wastes in the drums are being tested for disposal designation. They will be removed from the site and properly disposed.
- ▶ **Local Patches of Hydrocarbon-Stained Soil.** The soil is being tested for characterization and disposal designation. Confirmation sampling of the excavated area is being conducted after excavation to verify complete removal. The soils will be disposed of properly.
- ▶ **Other Debris.** Miscellaneous nuisance debris such as an asbestos wallboard and pipe, scrap metal, roofing felts, household wastes, and tires have been removed and appropriately disposed.
- ▶ **Septic Tank and Sludge Contents.** The sludge has been removed and properly disposed. The tank will remain on the site.

Atochem is completing a soils and groundwater investigation of the Ag-Chem (Wypenn) area which borders on a portion of the Blair Backup property (See Boating & Associates January 1992 Hydrogeologic Investigation Wypenn Area Atochem North American, Inc.). Reporting of the investigation findings is expected in early 1992. Former investigation and cleanup activities conducted at the Ag-Chem site include removal of high pH sludge from a former waste pond (Aware, 1981 and Kennedy/Jenks/Chilton, 1990).

2.6 Report Organization

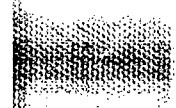
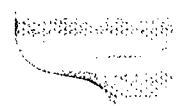
Data generated from both phases of field work were compiled and evaluated to produce this report. Following the Executive Summary, Introduction, and Scope of Work sections, we present a more detailed discussion of the site geology and hydrogeology; soil and groundwater quality relative to numerical criteria; risk assessment; and conclusions and recommendations.

References, tables, and figures follow the main body of the text. A plate showing surveyed sampling locations is included at the back of the report. We conclude the report with 4 volumes of appendices detailing our field methods, laboratory testing, and other information in support of our work. See the Table of Contents for the specific location of information of interest.

2.7 Limitations of This Work

This work was completed in accordance with contract E-1192 dated February 22, 1989, between the Port and Hart Crowser, Inc. All MTCA cleanup levels included in this report are provided as a conservative means of comparison only. This does not represent a MTCA interpretation, nor is it implied that remedial actions at this site may or may not be required under MTCA. Specific MTCA interpretations may involve separate calculations and determinations upon which a range of cleanup standards may be negotiated. The human health risk assessment was based on assumptions developed by EPA Region 10 in 1989, 1990, and 1991 which were current at the time the risk portion of this text was completed. This work was performed and this report prepared in accordance with generally accepted professional practices for the nature of the work completed in the same or similar localities, at the time the work was performed. No other warranty, express or implied, is made.

3.0 Scope of Work



3.0 SCOPE OF WORK

Based on the findings of the Phase I Blair Backup property environmental audit (Hart Crowser, 1989), Hart Crowser prepared a Phase II Work Plan (Hart Crowser, 1989b) and Work Plan Addendum (Hart Crowser, 1990b) to verify the Phase I findings and to address the nature and extent of contamination (if present) at the property. Field activities were completed between December 1989 and April 1991 in accordance with these work plans.

The primary objectives of our sampling and analysis program for the Blair Backup property were to:

- ▶ Characterize subsurface geologic and hydrogeologic conditions;
- ▶ Evaluate the possible transport of contaminants onto the site from adjacent properties including Pennwalt, Kaiser Aluminum, and Reichhold Chemical properties as well as potential migration of contaminants derived from on-site activities;
- ▶ Screen for the possible presence of trace metals and organic constituents derived from historical activities and from fill materials imported to the site;
- ▶ Provide an evaluation of site conditions compared to existing numerical standards and relevant cleanup objectives; and
- ▶ Provide data to be incorporated into a risk assessment and evaluation of cleanup requirements, as necessary.

3.1 *Field Activities*

Field activities needed to accomplish these objectives were performed in two phases. The first phase (Phase I) of field work was conducted from December 1989 to February 1990. The second phase (Phase II) of field work was conducted from August 1990 through April 1991. This work was performed to improve our understanding of the nature and extent of contaminants identified in the first phase of work as well as their potential sources.

This section discusses the quantity and types of explorations conducted at the Blair Backup property during these phases of field work.

Test Pit Excavation

During the first phase of our exploration program 35 test pits were excavated on the Blair Backup property to depths ranging from 1.5 to 10.5 feet below ground surface. An additional 12 test pits were excavated to depths of 2 to 7 feet below ground surface during the second phase of exploration. Test pit locations are shown on Figure 6. Test pit logs, soil sampling procedures, and soil sample descriptions are presented in Appendix A.

Soil Borings

A total of 26 shallow borings and 11 intermediate borings were drilled during our exploration program. Seventeen of shallow borings and all of the intermediate borings were completed during Phase I. The shallow borings were drilled to depths ranging from 9 to 17 feet below ground surface while the depths of the intermediate borings ranged from 24 to 42.5 feet below ground surface. The other 9 shallow borings were completed during the second phase in 2 stages in August and October of 1990. These borings were drilled to depths ranging from 6.5 to 9 feet below ground surface. Boring logs, soil sampling procedures, and soil sample descriptions are presented in Appendix A. The location of all borings are shown on Figure 5.

Subsurface Soil Analyses

One to two subsurface soil samples from each boring, except for HC-20S, and from 31 of the test pits were submitted to Laucks Testing Laboratories, Inc. (Laucks), for chemical analysis. A total of 79 soil samples were selected for analysis based on sample depth, visual evidence of contamination, and sample recovery. The analyses conducted on the subsurface soil samples are summarized in Tables 1 and 2.

Most of the soil samples collected during the first phase of the exploration program were analyzed for total metals (EPA method 6010 or 7000 series) and hydrocarbons using GC-FID screening methods

(modified EPA method 8015). In addition, the following analyses were performed:

- ▶ EP Tox Metals (EPA method 335.3, 7 samples);
- ▶ Volatile Organic Compounds (EPA method 8240, 19 samples);
- ▶ Semivolatile Organic Compounds (EPA method 8270, 16 samples);
- ▶ Organophosphorus Pesticides (EPA method 8140, 9 samples); and
- ▶ Pesticides/PCBs (EPA method 8080, 12 samples).

Soil samples collected in the second phase of sampling were analyzed for the following:

- ▶ Total metals (EPA method 6010 or 7000 series, 14 samples);
- ▶ Volatile Organic Compounds (EPA method 8240, 5 samples);
- ▶ Semivolatile Organic Compounds (EPA method 8270, 11 samples);
- ▶ Total Petroleum Hydrocarbons (EPA method 418.1, 7 samples); and
- ▶ Hydrocarbons using GC-FID screening (modified EPA method 8015, 21 samples).

Surface Soil Sampling and Analyses

During the first phase of sampling, a total of 8 surface soil samples were collected. All samples were submitted for GC-FID screening (modified EPA method 8015). In addition, selected samples were submitted for the following analyses:

- ▶ EP Tox Metals (EPA method 335.3, 3 samples);
- ▶ Volatile Organic Compounds (EPA method 8240, 1 sample); and
- ▶ Semivolatile Organic Compounds (EPA method 8270, 2 samples).

Eleven surface soil samples were collected during the second phase of work. All samples were GC-FID screened (modified EPA method 8015). The following analyses were also performed on selected samples:

- ▶ Total metals (EPA method 6010 or 7000 series, 6 samples);
- ▶ TCLP metals (EPA method 1311, 5 samples);
- ▶ Semivolatile Organic Compounds (EPA method 8270, 2 samples); and
- ▶ Total Petroleum Hydrocarbons (EPA method 418.1, 2 samples).

Several samples of charcoal and wood were collected on the Blair Backup property. These samples were submitted for GC-FID screening (modified EPA method 8015), semivolatile organic compounds (EPA method 8270), and TPH (EPA method 418.1) analyses.

Sample procedures and descriptions are given in Appendix A and sample locations are shown on Figure 7.

Ditch Sediment Sampling and Analyses

Four composite and discrete samples of ditch sediment were obtained from the OFA Ditch. These samples were analyzed for:

- ▶ Total metals (EPA method 6010 or 7000 series);
- ▶ Semivolatile organics (EPA method 8270); and
- ▶ Total organic carbon (EPA method 9060)

Seven discrete and composite sediment samples were taken at varying depths from the Pennwalt Ag-Chem Ditch and analyzed for:

- ▶ Total metals (EPA method 6010 or 7000 series, 5 samples);
- ▶ PAHs (EPA method 8310, 4 samples);
- ▶ Pesticides/PCBs (EPA method 8080, 5 samples);
- ▶ Organophosphorus Pesticides (EPA method 8140, 4 samples);
- ▶ GC-FID screening (Modified EPA Method 8015, 1 sample);
- ▶ Chlorinated Herbicides (EPA method 8150, 5 samples);
- ▶ Volatile Aromatic Compounds (EPA method 8020, 6 samples); and
- ▶ Total organic carbon (3 samples).

Sample locations are shown on Figure 7.

Surface Water Sampling and Analyses

A total of four surface water samples were collected with three from the OFA Ditch and one from the Pennwalt Ag-Chem Ditch. Sample locations are shown on Figure 7. All samples were submitted for analysis of total metals-(EPA method 6010 or 7000 series). In addition, the Ohio Ferro-Alloy samples were analyzed for dissolved metals (EPA method 6010 or 7000 series) and the Pennwalt Ag-Chem Ditch sample was submitted for GC-FID screening (Modified EPA method 8015) and chlorinated herbicide analysis (EPA method 8150).

Monitoring Well Installation and Development

Monitoring wells were completed in 21 of the shallow borings and all 11 of the intermediate borings. Monitoring well construction logs and installation and development procedures are presented in Appendix A.

Groundwater Sampling and Analysis

Three rounds of groundwater sampling were performed in the monitoring wells on the Blair Backup property. During the January 1990, October 1990, and December 1990 sampling rounds, a total of 33, 13, and 37 samples were collected, respectively. Sampling procedures are described in Appendix A. The groundwater sampling analyses conducted are summarized in Table 3. All groundwater samples were submitted to Laucks for the following analyses:

- ▶ Dissolved metals (EPA method 6010 or 7000 series);
- ▶ Volatile organic compounds (EPA method 8240);
- ▶ Semivolatile organic compounds (EPA method 8270); and
- ▶ Total dissolved solids (EPA method 160.1).

For the January sampling round, all samples were also submitted for Pesticides/PCBs (EPA method 8080), and for the October and December sampling rounds total suspended solids analysis (EPA method 160.2) was performed.

In addition to the above analyses, selected groundwater samples collected during the December sampling round were submitted for the following analyses:

- ▶ Fluoride (EPA method 340.2);
- ▶ Hardness as CaCO_3 (EPA method 130.2);
- ▶ Organophosphorus Pesticides (EPA method 8140);
- ▶ Chlorinated Herbicides (EPA method 8150);
- ▶ Calcium (EPA method 7140);
- ▶ Chloride (EPA method 325.3);
- ▶ Hydrogen Sulfide as S;
- ▶ Magnesium (EPA method 7450);
- ▶ Sodium (EPA method 7770);
- ▶ Sulfate as SO_4 (EPA method 375.4); and
- ▶ Total alkalinity as CaCO_3 (EPA method 310.1).

Water Level Monitoring and Tidal Response Assessment

Groundwater levels were measured in selected shallow and intermediate monitoring wells on January 19, 1990, February 2, 1990, February 7-9, 1990, September 11, 1990, and January 25, 1991. Water levels were also measured at several surface water locations at these same times. Water level data are presented in Table A-1 in Appendix A. In February 1990 three shallow wells and three intermediate wells were continuously monitored with an automated data acquisition system during one tidal cycle. These data were used to assess the response of the aquifer to tidal fluctuations. Plots of these measurements are presented on Figures A-57 and A-58 in Appendix A.

Hydraulic Conductivity Testing

In situ hydraulic conductivity tests (slug tests and bailer tests) were conducted in twenty monitoring wells during Phase I and in two additional wells during Phase II. The response data from these tests were analyzed using standard methods developed by Bouwer and Rice (1976) to estimate hydraulic conductivities in the soils adjacent to the monitoring well screen sections. In addition selected soil samples from the well borings were tested to determine their grain size characteristics. Using Hazens method these grain size data were used to estimate hydraulic conductivity of the soils for comparison to the *in situ* results. Testing procedures, grain size distribution curves (Figures A-59 and A-60) and estimated hydraulic conductivity (Table A-2) are presented in Appendix A.

3.2 Other Work Items

In addition to these project-specific activities we also conducted specialized studies related to the project property. These studies and the respective appendices presenting the results are as follows:

- ▶ Determination of Local Soil Reference Concentrations (Appendix D)
- ▶ Determination of Local Groundwater Reference Concentrations (Appendix D)
- ▶ Asbestos Assessment Survey (Appendix E)
- ▶ Nuisance Materials Documentation (Appendix F)

- ▶ Identification of Subsurface Structures in Ohio Ferro-Alloy Area (Appendix F)
- ▶ Slag Geochemical Analytical Assessment (Appendix F)
- ▶ Quantification of Human Exposure and Risk (Appendix G)
- ▶ Toxicity Profiles (Appendix H)
- ▶ Historical Review of Ohio Ferro-Alloy Facility (Appendix I)
- ▶ Formaldehyde Analysis Assessment (Appendix J)
- ▶ Iron and Manganese Assessment (Appendix K)
- ▶ Comparison of Soil Quality Data with MTCA Residential/Commercial Cleanup Levels (Appendix L)

3.3 Review of Existing Documents

As part of this work, we reviewed numerous reports describing soil, sediment, and water quality on adjacent properties (Reichhold, Atochem, and Kaiser) as well as investigations conducted on the Blair Backup property by Ecology (1984), Hart Crowser (1986b and 1989a), Ecology and Environment (1987), CH2M Hill (1989c and 1989d), GeoEngineers (1990), and Landau (1990). Results of these investigations were used to supplement site characterization data collected as part of this study.

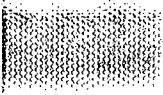
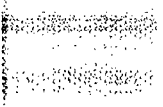
3.4 Deviations from the Work Plan

Field activities conducted on the Blair Backup property generally followed the scope of work outlined in our Work Plan (Hart Crowser, 1989) and Work Plan Addendum (Hart Crowser, 1990b). Major deviations from these work plans include the following:

- ▶ Installed four additional borings adjacent to the former Pennwalt Experimental Laboratory and completed two of the borings as monitoring wells;
- ▶ We could not install two of the three North Site Area monitoring wells proposed in Task 4 of the Supplemental Work Plan because no aquifer units were encountered within the depth of exploration;
- ▶ Only one of the two OFA drainage ditch surface water samples proposed in Task 1 of the Supplemental Work Plan was collected. Since the drainage ditch was blocked and no flow was observed, we

could not collect two samples at different flow rate conditions as proposed;

- ▶ We could not sample groundwater from all of the site wells during the dry season (Task 8 of the Supplemental Work Plan) since many of the shallow wells went dry or contained too small of a volume of water for sampling; and
- ▶ The specific scope of work for Port of Tacoma groundwater background sampling (Hart Crowser, 1991) was not reviewed or commented on by EPA or Ecology.



4.0 HYDROGEOLOGY OF THE STUDY AREA

Understanding the hydrogeology of the Blair Backup property is essential in characterizing contaminant risks on the site. The geology of the site, coupled with patterns of recharge and discharge, define the groundwater flow system. Groundwater flow provides one of the principal pathways for potential contaminant migration. This section describes the hydrogeologic conditions at the Blair Backup property and its relationship to the regional hydrogeologic framework.

4.1 Regional Geology

The Blair Backup property is located in the Commencement Bay tideflats area on a peninsula between the Blair and Hylebos Waterways. The tideflat area lies at the mouth of the Puyallup River Basin. In this area the basin is comprised of a thick sequence of alluvial and marine sediments deposited in a deep embayment that was carved by several glacial episodes.

The depositional history has resulted in four major geologic units beneath the property area that are of significance to our study of the site. From the ground surface down these include:

- ▶ **Recent Fill Deposits.** These materials blanket the property with thickness ranging from a few feet to slightly over 10 feet. The fill primarily includes silt and sand dredged from the Blair and Hylebos Waterways in the 1950s and 1960s, and gravelly borrow source material.
- ▶ **Deltaic/Alluvial Sediments.** These sediments were deposited by the Puyallup River which flowed out of the Cascades and emptied into Puget Sound. A large delta formed at the mouth of the river in the present day Commencement Bay area leaving over 100 feet of sediments. The delta consists primarily of sequences of silt and sand. The surface of the delta constitutes the former tideflat surface, laced with a tributary system of streams and tidal channels.
- ▶ **Marine Sediments.** A thick sequence of marine sediments lies below the delta deposits. These sediments were deposited in a deep marine trough believed to be at the mouth of the Puyallup River at a time when sea level was higher. The marine sediments are

primarily fine-grained silts and clays and are estimated to be over 300 feet thick in the project area.

- **Glacial Sediments.** A thick sequence of glacial sediments underlies the marine and deltaic sediments in an occurrence pattern which outlines the trough into which the river sediments were deposited. The glacial sediments are predominantly sands, gravels, and silts estimated to be over 1,000 feet thick in the Puyallup Valley. It is within the glacial deposits that the principal water supply aquifers of the region lie.

4.2 Regional Groundwater Flow

The regional groundwater flow is one of recharge in the upland areas and discharge to the river valley and Puget Sound. In recharge areas groundwater flow has a downward component while in discharge areas there is an upward flow component. Infiltrating precipitation in the upland areas southeast and southwest of the project area tends to move downward and laterally toward the Puyallup River Basin. Once in the deep sediments of the river basin the groundwater moves upward and laterally to discharge to the Puyallup River and Puget Sound.

The regional flow system occurs within the deep deltaic and glacial sediments. There is a strong upward flow gradient between the water supply aquifers within these deposits and the shallower aquifers in the Port area. The upward flow component provides protection from downward industrial contamination migration. A shallower flow system exists within the shallow deltaic and fill sediments that were the principal units evaluated for this project. The shallow flow system in the area is the most heavily influenced by local drainage features and the tides.

4.3 Surface Water Drainage

The surface water system interacts with the Shallow Aquifer providing both recharge and discharge pathways for the aquifer. The most significant surface water features are shown on Figure 4.

Much of the Blair Backup property is poorly drained although there are a few defined drainages along the periphery of the property. Standing water from precipitation is common during the wet season (see Figure

4), particularly in the OFA/Pennwalt Area and the southeast section of the General/Fill Area. Because of filling, piles of debris, and various short-term localized property uses, there is no naturally established drainage system. Man-made drainages have been frequently altered. Irregular topography and fine-grained surface soils cause abundant ponding observed during our wet season field activities. These areas act to recharge the Shallow Aquifer system.

The Reichhold S (South) Ditch is the most prominent drainage feature on the property. The ditch begins in the central North Site Area and runs south where it discharges into the deep well-defined ditch which parallels the south Reichhold fenceline. The bottom of this part of the ditch is over 8 feet below ground surface. Observations indicate that water flowing in the ditch is tidally influenced. From the southeast property corner the ditch goes into an underground culvert and ultimately discharges to the Blair Waterway. Shallow groundwater from much of the property discharges to the Reichhold S Ditch.

The Pennwalt Ag-Chem Ditch is a well-defined ditch which exists along the western fenceline of the Pennwalt Ag-Chem facility. The Commencement Bay, Nearshore/Tideflats Area Drainage Map (TPCHD, 1988), indicated stormwater drainage from this ditch westward to the Reichhold S Ditch. The Pennwalt Ag-Chem Ditch still exists although the drainage path toward the Reichhold S Ditch has been interrupted by debris fill piles. It appears that this ditch no longer has an outflow and water in the ditch will either evaporate or infiltrate to the Shallow Aquifer.

In the OFA/Pennwalt Area, along the Kaiser Aluminum property boundary, is the OFA Ditch. This ditch, at one time, discharged to a piped subsurface drain. During the period of investigation, the drain was clogged with wood chip debris and there was little to no flow of water through the drain. The poor drainage is part of the cause for ponding that is seen over much of the OFA/Pennwalt Area.

Wet areas in the western North Site Area and the northern General/Fill Area exist throughout most of the year and are possibly caused by upwelling groundwater that intersects the ground surface.

4.4 Property Area Hydrogeology

The hydrogeology of the Blair Backup property was evaluated by reviewing existing geologic and hydrologic data and by completing a monitoring well drilling and testing program. The existing data provided information on the general conditions in the surrounding area while the field program provided site-specific information. The principal existing information reviewed included:

- ▶ Pennwalt Hydrogeologic and Engineering Evaluation on Hazardous Waste Facilities (Aware, 1981) and discussions with Atochem (formerly Pennwalt) and Ecology on recent data and findings;
- ▶ Reichhold RCRA Part B permit documents and associated investigation and monitoring reports (CH2M Hill, 1987a, 1987b, 1987c, 1988b, 1989b, and 1991);
- ▶ Kaiser RCRA Part B permit documents (Kaiser, 1987);
- ▶ Ecology and Environment, Site Inspection Report for Commencement Bay Nearshore/Tideflats, prepared for EPA (Ecology and Environment, 1987); and
- ▶ Hart Crowser files on Commencement Bay projects (Hart Crowser, 1974, 1986a, 1986b, 1988, 1989a, 1990a, and 1990b).

We obtained site-specific information by drilling, logging and sampling 26 shallow and 11 deeper borings (Figure 5). Monitoring wells were completed in 21 of the shallow borings and all of the deeper borings with each of the deeper wells being paired with a shallow well. These well clusters provide data on vertical hydraulic gradients. Hydrologic data were gathered by water level monitoring, tidal evaluation and *in situ* hydraulic conductivity testing in the wells. In addition to the borings, 47 test pits were excavated, logged, and sampled at the locations on Figure 6. The well and test pit data were used to interpret the stratigraphy and groundwater flow beneath the property to provide a basis for evaluating the occurrence and transport of any subsurface contaminants.

4.4.1 Hydrogeologic Units

Subsurface soil data collected from borings completed to a maximum depth of about 42 feet indicate an alternating sequence of sand and silt. The geologic deposits encountered include the Recent Fill and the underlying native Deltaic/Alluvial sediments.

Three principal hydrogeologic units were identified that are generally consistent with units identified in the surrounding property areas. These units are discussed as the Shallow Aquifer which occurs within the recent fill deposits, an Upper Aquitard which is encountered at the native tideflat surface, and below this, an Intermediate Aquifer within the Deltaic Deposits. This nomenclature is consistent with work performed on surrounding properties.

Hydrogeologic cross sections were constructed from the subsurface data. These subsurface depictions are presented on Figures 8 through 10. The boring logs and well construction data are presented in Appendix A. These data provide the basis for discussion of the occurrence, material type, thickness, and extent of the hydrogeologic units.

Shallow Aquifer. The Shallow Aquifer occurs within the Recent Fill. The fill materials are highly variable in material type and thickness. The data showed the fill to range in thickness from 7 to 13 feet, with an average of 10 feet on the property. In general, there is a surficial layer of gravelly fill which is underlain by a silty sand. In the OFA/Pennwalt Area the gravelly fill is as thick as 8 feet in some areas, and contains ore and slag material, and wood chips (Figures 8 and 10). Silty to gravelly sand fill also occurs in the North Site Area, and in the southwest of the General/Fill Area (Figures 8 and 9). Below the surficial gravelly sand lies slightly silty to silty sand that represents the typical dredged material found throughout the Port area (Hart Crowser, 1974).

The ore, slag, and waste rock in the OFA/Pennwalt Area comprise waste materials from the former OFA plant that existed on site. Wood chips occur throughout the OFA/Pennwalt area as a result of former log yard operations and Asarco slag is observed scattered about the surface around this portion of the property. Figure 11 depicts the areal extent and thickness of this slag/fill material as identified during our field work.

It is estimated that approximately 100,000 to 150,000 cubic yards of this material exist on the property.

Groundwater is usually encountered within a few feet of ground surface in the Shallow Aquifer. The Shallow Aquifer is generally unconfined, although the water level observed at the time of drilling often rose several feet in the completed well. This is common in moderately low permeability sediments like those comprising the silty sand aquifer.

The saturated thickness of the Shallow Aquifer ranged from about 1 to 13 feet during the wet season monitoring with a mean of about 7 feet. During the dry season, the Shallow Aquifer is unsaturated in the western part of the property where the underlying aquitard exists at higher elevations. The saturated thickness during this monitoring period ranged 0 to 8.5 feet with an average of approximately 5 feet.

Upper Aquitard. The Upper Aquitard is encountered beneath the Shallow Aquifer at the native tide flat surface. This contact is marked by the occurrence of a clayey, highly organic silt overlying the silt, clayey silt, and/or organic silt that generally make up the aquitard. The aquitard ranges in thickness from 5 to 19 feet and was an average of 10 feet thick in the wells drilled into the Intermediate Aquifer. It was thinnest around HC-6 in the northern portion of the OFA/Pennwalt area and in HC-10 in the west-central OFA/Pennwalt Area. In these areas the silt is interbedded with silty sand layers. These sand layers may be related to the location of a former stream channel on the property (USGS, 1980, and Figure 12).

Intermediate Aquifer. The Intermediate Aquifer lies below the Upper Aquitard and consists of a silty to slightly silty sand. The bottom of this unit was encountered in only two of our wells (HC-6I and HC-16I). Based on these two data points and data from the surrounding areas, the thickness of this aquifer is estimated to range from 5 to greater than 13 feet on the property. The Intermediate Aquifer is confined with piezometric water levels ranging from 5 to 14 feet below ground surface during the wet season and 1 to 2 feet lower in the dry season.

Deeper Units. In the surrounding areas (Reichhold, Kaiser, and Atochem) a deeper aquitard and aquifer have been explored and tested. The deeper aquitard is referred to as the Lower Aquitard and below that a sandy unit is referred to as the Deep Aquifer. These units

were not explored as part of this investigation because data evaluated during the Phase I work indicated it was unlikely that groundwater contamination would exist on the property at these greater depths. Data collected as part of this work support this finding.

4.4.2 Groundwater Flow System

The groundwater flow system is discussed with respect to horizontal flow within the Shallow and Intermediate Aquifers and vertical flow through the Upper Aquitard between these aquifers. Groundwater flow is a function of gradient, hydraulic conductivity, and porosity. Directions and rates of flow at the property are discussed below based on estimates of gradient and hydraulic conductivity for each of the hydrogeologic units. We have assumed porosity values from literature (Freeze and Cherry, 1979) for the various material types.

Evaluation of the groundwater flow system is based on water level measurements made in wells installed on the Blair Backup property and selected wells on adjacent properties. There were three primary water level monitoring events: February 1990 and January 1991 for evaluation of wet season groundwater flow patterns; and September 1990 for evaluation of dry season patterns. In addition, three shallow and three intermediate wells were monitored over a 2-day period to evaluate tidal influences. The water level data are presented in Table A-1 in Appendix A. Figures 12 through 17 present the water level contour maps for the Shallow and Intermediate Aquifers for these monitoring events.

Shallow Aquifer. Groundwater flow within the Shallow Aquifer is influenced primarily by variability of the fill materials and surface water features. The Shallow Aquifer is not influenced by tides in this area because the aquifer is sufficiently above the mean tide level. The groundwater flow regime varies somewhat between the wet and dry seasons and these differences are discussed. The most prominent Shallow Aquifer flow features include:

- **Flow toward the Reichhold S Ditch.** The Reichhold S Ditch acts as a receptor for much of the groundwater in the Shallow Aquifer. Cross Section D-D' (Figure 9) shows the ditch to intersect the full thickness of the Shallow Aquifer and part of the Upper Aquitard. Thus, the ditch acts as a cutoff for groundwater transfer between

either side of the ditch. Currently, groundwater around the Reichhold S Ditch moves toward the ditch during the wet season (Figures 12 and 14). However, during operation of the Shallow Interceptor Drain on the Reichhold property, groundwater in the Shallow Aquifer (on the Reichhold side of the ditch) may no longer contribute to flow in the Reichhold S Ditch. In addition, the geologic data indicate the Upper Aquitard bulges upward in the vicinity of borings HC-20 and HC-22. Groundwater flow toward the Reichhold S Ditch and this aquitard high may contribute to the wetlands in this area.

During the wet season, hydraulic gradients toward the Reichhold S Ditch range from 0.008 to 0.015 in the General/Fill Area and 0.005 to 0.007 in the North Site Area. In the OFA/Pennwalt Area, the hydraulic gradients are 0.004 to 0.008 toward the ditch/wetland area. In the dry season the hydraulic gradients toward the wetland are approximately 0.004 to 0.005, 0.003, and 0.002 in the General/Fill, OFA/Pennwalt, and North Site Areas, respectively.

- ▶ **Groundwater Mound in the General/Fill Area.** A local Shallow Aquifer groundwater high exists around wells HC-14S and HC-18S. This area was ponded with water at the time of our monitoring and during most of the field work. Fine-grained soils with low hydraulic conductivity characteristics may be the cause for slow infiltration in this area causing a mounding condition. From the mound, flow to the north toward the OFA/Pennwalt Area and west toward the Reichhold S Ditch occurs. Well HC-17S indicates that flow also occurs to the south from this high.
- ▶ **Flow toward Taylor Way.** The shallow groundwater along the eastern portion of both the North Site Area and OFA/Pennwalt Area is moving toward Taylor Way. Well HC-16S represents some of the lowest water level elevations measured in the Shallow Aquifer. A low in this area is coincident with a low on the Atochem side of Taylor Way.

Flow toward Taylor Way is probably influenced by coarse-grained soils used for utility trench backfill in the utility corridors that occur beneath the east side of the road. The sanitary sewer is constructed to depths of over 9 feet below ground surface, into the Upper Aquitard along the property boundary that parallels the road

(Figure 9). Excavation of one of these deep trenches for pipe repairs was observed during our Phase I site reconnaissance at which time we noted groundwater seepage (Hart Crowser, 1989a).

If groundwater is not intercepted by the utility trench backfills then flow onto the Atochem site occurs during at least a portion of the year. These groundwaters would mix with the groundwater beneath the Atochem facility. The potential for the Blair Backup property groundwaters to mix with the Atochem groundwaters will be enhanced when Atochem groundwater extraction system goes into operation. It is likely the capture zone of their extraction system will encompass flows from the Blair Backup property (personal communication, Fred Wolf and Tom McKuen).

Hydraulic gradients toward Taylor Way through the eastern OFA/Pennwalt Area ranged between approximately 0.003 and 0.006 during both the wet and dry seasons monitoring. The hydraulic gradient toward Taylor Way in the northernmost property area where flow is from Reichhold, through the Blair Backup property, was approximately 0.004 to 0.006 during the wet season monitoring. The September 1990 (dry season) flow in this area appears to be toward the wetland.

- **Groundwater Divide in the North Site and OFA/Pennwalt Areas.**
The water table surface is fairly flat in the western OFA/Pennwalt Area extending north along the western boundary of Pennwalt Ag-Chem property and into the North Site Area. There appears to be a divide in this general area with water directed toward Taylor Way on one side and toward the Reichhold S Ditch on the other. Standing water was observed around HC-11, in the Pennwalt fenceline ditch, and throughout the west half of the OFA/Pennwalt Area during the wet season water level monitoring. These ponded areas would act to recharge the Shallow Aquifer. Flow from this central property/recharge area toward the North Site wetland area and Taylor Way cause the apparent divide.

This divide shifts slightly with time and is reflective of the amount of recharge the area receives. Low hydraulic gradients in this area create the lowest flow rates observed on the property.

Intermediate Aquifer. As with the Shallow Aquifer, the Intermediate Aquifer is not significantly influenced by tides on the Blair Backup property. The maximum observed tidal fluctuation was 0.36 foot in HC-14I, the well closest to the Blair Waterway. This minor fluctuation is due to its distance from the waterway and the transmissivity of the aquifer sediments. These observations are consistent with the data collected by Reichhold and Pennwalt which roughly indicate Taylor Way and Alexander Avenue as the furthestmost reach of significant aquifer tidal response. Tidal monitoring data for the Shallow and Intermediate Aquifers is presented on Figures A-57 and A-58 in Appendix A.

Flow in the Intermediate Aquifer on the property is most heavily influenced by a low water level elevation measured in HC-12I on the border of the General/Fill and OFA/Pennwalt Areas. Groundwater flow is directed toward the center of the property because of this low. Nearing the property boundaries along the roads (Taylor Way and Alexander Avenue), flow begins to be directed toward the Hylebos and Blair waterways (respectively). There is little difference in the rates and directions of flow between the wet and dry season monitoring.

Hydraulic gradients toward the center of the Blair Backup property within the Intermediate Aquifer ranged from 0.001 to 0.005. Higher gradients are observed during the wet season and lower gradients during the dry season.

Downward Vertical Flow. There is a downward component of groundwater flow within the Shallow Aquifer beneath the entire property. Vertical gradients ranging from 0.2 to 0.9 across the Upper Aquitard are directed downward and indicate groundwater movement from the Shallow Aquifer to the Intermediate Aquifer. These gradients are fairly consistent between wet and dry seasons with slightly higher gradients during the wet season in the General/Fill Area.

4.4.3 Hydraulic Conductivity

The hydraulic conductivity of the Shallow and Intermediate Aquifers was evaluated by performing *in situ* testing and grain size analysis. The hydraulic conductivity is a measure of the ability of water to flow through the aquifer. Twenty tests were performed in wells on the Blair Backup property; fifteen tests were conducted in Shallow Aquifer wells and five tests were conducted in Intermediate Aquifer wells. The

testing and analysis methods are discussed in Appendix A. The estimated hydraulic conductivity values are presented in Table A-2.

The hydraulic conductivity of the Shallow Aquifer ranged from 5×10^{-3} to 1×10^{-4} cm/sec. This range and magnitude are typical of silty sand soils within which the local aquifer occurs. The geometric mean of the hydraulic conductivity values is approximately 7×10^{-4} cm/sec. The geometric mean is an appropriate representation of the hydraulic conductivity of a heterogeneous material such as the fill which comprises this aquifer.

The measured hydraulic conductivity of the Intermediate Aquifer was variable and ranged from approximately 7×10^{-4} to 1×10^{-2} cm/sec. The geometric mean of these data is approximately 1×10^{-3} cm/sec. Based on observations at the East-West Road property (also being transferred to the Tribe under the Puyallup Tribe of Indians Settlement Act of 1989) and pumping of the Intermediate Aquifer at the Reichhold site, it is likely that the hydraulic conductivity of the Intermediate Aquifer is toward the upper end of the observed range.

The vertical hydraulic conductivity of the Upper Aquitard is estimated to be within the range of 5×10^{-6} to 5×10^{-7} cm/sec. Although specific testing of this layer was not conducted for this study, data for the aquitard in the surrounding areas indicate hydraulic conductivities in this range.

4.4.4 Groundwater Flow Rates

Groundwater flow rates are presented as the average linear velocity along the flow paths identified from the contour maps. Flow rates were estimated using the hydraulic conductivities and gradients discussed above for each flow path. A porosity of 0.3 was assumed based on literature values for sand and silty sand deposits. The parameters used in our flow rate estimates are summarized in Tables 4 and 5 for the Shallow and Intermediate Aquifers, respectively.

Shallow Aquifer. Flow rates in the Shallow Aquifer were estimated for the principal flow paths identified in Section 4.4.2 Groundwater Flow System. The February 1990 and January 1991 water level monitoring data are presented as the wet season, and the September 1990 monitoring data are presented as the dry season.

Estimated flow rates during the wet season ranged from 0.02 to 0.09 ft/day while dry season flow rates were approximately 0.01 to 0.03 ft/day. Flow rates for each of the principal flow paths are summarized in Table 4. We have also estimated the total volume of flow through each other major subareas using these flow rates.

Intermediate Aquifer. Flow directions identified in the Intermediate Aquifer by the monitoring data indicate much of the flow to be toward the center of the site. Flow rates to this center area range from 0.01 to 0.02 ft/day from the Reichhold property side to 0.04 ft/day from the Kaiser side during February 1990. Wet and dry season flow rates are shown in Table 5.

Upper Aquitard. Vertical flow rates through the Upper Aquitard are estimated to be 0.0007 to 0.04 ft/day based on the following parameters:

- ▶ Hydraulic conductivity in the range of 5×10^{-6} to 5×10^{-7} cm/sec;
- ▶ Vertical hydraulic gradients ranging from 0.2 to 0.9; and
- ▶ Porosity about 0.3 to 0.4 based on literature values for silty sand to clayey silt sediments.

4.5 Aquifers Not Suitable as Drinking Water Source

The Shallow and Intermediate Aquifers on the Blair Backup property are not considered suitable for drinking water supply. The Shallow Aquifer has an insufficient capacity to yield a sustainable supply and the Intermediate Aquifer is naturally of poor quality due to the mixing with saline waters. We offer the following data to demonstrate that these aquifers should not be considered as drinking water sources under MTCA guidelines [WAC 173-34-720(1)].

- ▶ The Shallow Aquifer is dry in a large portion of the General/Fill Area during the fall season, indicating groundwater pumping would not be sustainable throughout the year. In addition, a Neuman (1975) analysis of flow to a well indicates that the maximum sustainable yield in the aquifer is less than 0.5 gpm MTCA criteria. Our analysis was based on the mean hydraulic conductivity (0.0007 cm/sec), an average saturated aquifer thickness of 6 feet, specific storage of 0.2, and an assumed well efficiency of 50 percent. Also

consider, by review of the volumetric flow data presented in Table 4, that the total volume of groundwater moving horizontally through the subareas is generally less than 0.5 gpm. It would be technically impossible to capture all of this groundwater from a single shallow well.

- The Intermediate Aquifer is of poor natural water quality as a result of mixing with saline waters. Figure 27 presents a contour map of average total dissolved solids (TDS) for the January and December 1990 sampling rounds. A large percentage of the property is above the 10,000 mg/L TDS MTCA criteria. The mean TDS value for all wells during those sampling rounds is approximately 9,600 mg/L with an upper 95 percent confidence level of about 14,600 mg/L.

The Intermediate Aquifer should not impact groundwater quality of deeper aquifers. Upward hydraulic gradients and thick silty sediments limit downward migration of groundwater between the aquifers of study and deeper aquifers with potential for water supply. The next aquifer, the so-called Deep Aquifer of the Reichhold and Kaiser investigations, is not suitable for water supply because of the high TDS which renders it "moderately saline" by USGS classification (CH2M Hill, 1987b).

There is an upward hydraulic gradient between the Intermediate and Deep Aquifers at least half the time on the Reichhold site due to tidal fluctuations. This will limit the flow of water between these two aquifers.

The only groundwater suitable for water supply in this area is within the glacial deposits that occur at depths of over 800 feet in this area. At least 300 feet of low permeability marine and alluvial silts occur between the aquifers studied on the property and deeper water supply aquifers restricting any contaminant transfer. In addition, there is a strong upward gradient between the water supply aquifers and the site aquifers. This is illustrated by wells tapping the water supply aquifers in the area (Kaiser, City of Tacoma, and Occidental) which are generally flowing with water levels above ground surface.

BLAIR.4

5.0 Soil and Water Quality

5.0 SOIL AND WATER QUALITY

The results of soil and water quality analyses performed as part of this assessment are discussed in this section. The criteria we used to evaluate the data are discussed first, followed by a presentation of the results by media. When we identify a potential contamination concern, a discussion of potential sources follows. This section is divided into the following six major sub-sections:

- ▶ **Screening Criteria** - Discusses our use of numerical criteria for screening soil, ditch sediment, and water quality data. We present MTCA cleanup levels for all the media because this state regulation is an ARAR under CERCLA and the Method B MTCA cleanup levels incorporate other potential ARARs.
- ▶ **Surface Soil, Subsurface Soil, and Sediment Quality** - Presents soil and sediment quality data for the three subareas defined for this investigation (See Figure 2). These subareas include the General Fill Area, the North Site Area, and the OFA/Pennwalt Area. Sediment quality data for the three on-site ditches are discussed within the subarea section by ditch name: Reichhold S Ditch, Pennwalt-AgChem Ditch, and OFA Ditch.
- ▶ **Surface Water Quality** - Discusses the surface water quality data by ditch in the following order: the Pennwalt-AgChem Ditch, the OFA Ditch, and the Reichhold S Ditch.
- ▶ **Groundwater Quality** - The groundwater section is subdivided by discussion of area background water quality, Shallow Aquifer water quality, and Intermediate Aquifer water quality. Groundwater concerns are identified by the subarea in which they dominate.
- ▶ **Alexander Avenue Strip Area** - Summarizes soil and water quality data collected by Reichhold for this area.
- ▶ **Summary of Soil, Sediment, and Water Quality Issues** - Summarizes the soil and water quality issues identified using this screening approach.

Summary of the analyses performed on soils and groundwater are presented in Tables 1, 2, and 3. Summary tables of the chemistry data are presented for each media by subarea in Tables 6 through 23. Tables summarizing individual soil, sediment, and water quality sample results are presented in Appendix C, Volume II. Laboratory reports are presented in four supplemental volumes to this report: Volumes III, IV, V, and VI. Our validation report of the laboratory data is presented in Appendix B.

Soil, sediment, and water quality data generated by this work were reviewed by an environmental geochemist to determine the validity of the data based on the project QA/QC plan requirements and general quality control criteria. Based on this review, the analytical results were deemed acceptable for the purposes of this work, with qualifications. EPA's Regional Water Quality Branch also reviewed the validity of the analytical data. Their comments are incorporated into this report.

5.1 Evaluation of Data With Screening Criteria

Soil and groundwater quality results were screened relative to area background or local reference conditions, and potentially Applicable or Relevant and Appropriate Requirements (ARARs) in an effort to identify chemicals of potential concern and assess whether remedial actions may be required at the site. Constituents analyzed in soil, sediment, groundwater, and surface water media, including constituents with detection limits greater than corresponding numerical criteria, were compared to the following existing or prospective ARARs:

- ▶ Model Toxics Control Act (MTCA) cleanup levels for soil, groundwater, and surface water (Chapter 173-340 WAC, February 1991),
- ▶ State surface water quality standards (Chapter 173-201 WAC), and
- ▶ Federal Clean Water Act criteria (40 CFR 136).

The Model Toxics Control Act (MTCA) cleanup levels were initially used to screen the data as they constitute an ARAR under CERCLA and incorporate other potential ARARs. In fact, the cleanup level used for the various media under MTCA guidelines is typically the most conservative standard that is relevant to the potential risk of that

constituent. MTCA has three methods (Methods A, B, and C) for determining cleanup levels as follows:

- ▶ Method A cleanup levels are designed for simple cleanups involving only a few contaminants for which criteria have been established, but may also be used in cases such as lead where no Method B or C cleanup levels have been determined or a background level has been established (i.e., Method A for arsenic);
- ▶ Method B is applicable to all sites and is a risk-based method for setting cleanup levels at sites with multiple contaminants; this method includes evaluation of ARARs and cleanup levels are based on the most conservative value (See the groundwater section 5.1.3); and
- ▶ Method C conditional cleanup levels are used for commercial and/or industrial sites or when it is not technically feasible or is impracticable to cleanup to Method A or Method B levels.

Exceedence of the MTCA cleanup levels does not necessarily indicate that remedial actions are required but this approach helps identify areas and constituents which require further evaluation. We evaluated the need for remedial actions at the site by considering the results of the comparison of environmental data to existing ARARs, the fate and transport of the identified chemicals of concern, the potential for sources from past site activities, and human health risk assessments. Constituents which exceed screening criteria are evaluated relative to their environmental fate and mobility in Section 6.0 and human health and environmental risks in Section 7.0.

5.1.1 Soils

We chose to screen site soil quality data relative to MTCA industrial cleanup levels (WAC 173-340-745[1]) after considering the following factors:

- ▶ The site is currently zoned for industrial/commercial purposes;
- ▶ The Blair Backup property is currently being used for industrial uses, has a history of industrial use, and will remain industrial under

terms of the Puyallup Settlement Agreement and the subsequent Port/Tribe Implementing Agreement.

- ▶ Adjacent properties are being used for industrial applications;
- ▶ For screening purposes, the site is located within a large industrial area; and
- ▶ Institutional controls are required under MTCA for sites that utilize MTCA industrial soil cleanup levels when needed to protect human health and the environment or to assure the integrity of a cleanup action. Institutional controls may include physical measures such as fences and signs, and/or legal and administrative mechanisms.

Soil quality data are compared to MTCA Method A and Method C industrial cleanup levels (there are no Method B levels for industrial site soils). Table 7 presents the MTCA soil and sediment cleanup levels used to screen the site data. For comparison, Appendix L provides a summary of the data relative to the MTCA Methods A, B, and C levels for residential and commercial use.

5.1.2 Ditch Sediment

Because there are currently no state or federal freshwater sediment criteria which could be used to evaluate drainage ditch sediment quality, we compared the sediment data to the following criteria;

- ▶ The Reichhold S Ditch sediment quality data to Puget Sound Marine Sediment Quality Criteria (Chapter 173-204 WAC), in part, because the ditch is tidally influenced, it discharges to the Blair Waterway, and there are currently no plans to fill the ditch.
- ▶ Pennwalt Ag-Chem and OFA ditch sediment quality data to MTCA industrial soil cleanup levels because they are seasonally dry, do not appear to support a significant aquatic population, and apparently do not drain water off of the site (or for any great distances) due to obstructions. These ditches basically act only as depressions where water collects during the rainy season.

Table 7 presents the soil and sediment criteria used to screen site data.

5.1.3 Groundwater

We compared site groundwater quality data to MTCA Method B marine surface water cleanup levels because groundwater in the Shallow and Intermediate Aquifers ultimately discharges into the Blair and Hylebos Waterways via surface water or groundwater pathways (see Subsection 4.4.2). As discussed in Section 4.5, the Shallow and Intermediate Aquifers on the Blair Backup property are not considered suitable for drinking water supply under MTCA due to poor yields (Shallow Aquifer) and poor natural water quality (Intermediate Aquifer).

The impact to surface waters would not occur closer than at the boundary where the groundwater discharges into the surface water body. It is significant to note that this site does not border on the Hylebos or Blair Waterways. Thus, the surface water criteria are a conservative means of evaluating the potential impact of groundwater discharge to the aquatic environment because natural attenuation processes will occur in any contaminant transport.

The MTCA Method B marine surface water cleanup levels were determined using the following procedure:

- ▶ Evaluate ARARs to see if they are sufficiently protective of human health (less than 10^{-5} excess cancer risk or a Hazard Index of one). ARARs include marine chronic, marine acute, and human consumption of aquatic organisms criteria (at 10^{-6} risk) established under the Clean Water Act (40 CFR 136) and/or state surface water quality regulations (173-203 WAC).
- ▶ If the most conservative ARAR is determined to be sufficiently protective, the ARAR is used as the MTCA Method B marine surface water cleanup level.
- ▶ If ARARs are not sufficiently protective (as defined above) or not available, the MTCA marine surface water criteria are calculated using non-carcinogenic or carcinogenic Method B equations presented in WAC 173-340-730(3).

A tabular summary of the ARARs and the MTCA Method B risk-based levels (10^{-6}) used to establish marine surface water cleanup levels criteria for screening is presented in Table 16. The table shows that either the most conservative of the ARARs or the Practical Quantification Limit (PQL) was used to screen the data. Although a 10^{-6} risk was used to determine the values used for comparison, the MTCA will allow a risk of 10^{-5} for industrial sites.

Routine detection limits for several inorganic constituents (including arsenic, mercury, and thallium) slightly exceed the MTCA Method B marine surface water cleanup levels. Routine detection limits for cadmium, nickel, and silver exceeded the marine cleanup levels during the first round of sampling (January 1990) but did not exceed these levels in subsequent sampling events (October 1990 and December 1990). The detection limits goals for the project, which are presented in the Quality Assurance Project Plan (Hart Crowser, 1989), were developed prior to the establishment of MTCA. In addition, much of the groundwater sampled at the Blair Backup property contained high concentrations of total dissolved solids which elevate the practical quantitation limits for many inorganic constituents.

5.2 Surface Soil, Subsurface Soil, and Sediment Quality

Assessment of soil and sediment quality is based predominantly on laboratory results for the samples collected. The samples were obtained by split-spoon sampling during drilling, sampling of test pits, and grab sampling of surface soil and ditch sediments. Subsurface sampling locations for drilling and test pits excavations are shown on Figures 5 and 6. Surface soil and ditch sediment sample locations are shown on Figure 7.

In general, the soil sampling locations were selected based on areas of identified or suspected soil quality concerns. Soil samples were selected for chemical analysis if observation or field screening suggested the potential for contamination. If no indications of concern were identified then a representative sample was chosen from the depth at which the suspected contamination might occur.

5.2.1 Area Soil Reference Concentration

For comparison purposes we prepared a summary of available published and unpublished background and area reference soil quality data for metals. These reference values provide a data set for comparison of site soil quality data with presumably non-contaminated or natural soil. These data can also assist in determining the need for cleanup actions. Appendix D provides a discussion of the reference data sources and how we derived local reference values. The values are presented in Table D-1 in Appendix D.

5.2.2 General/Fill Area

Surface Soils. Two surface soil samples were collected in the General/Fill Area in areas of suspected contamination; one was obtained from a 5- to 10-cubic-yard pile of sandblast waste (SS-9) that was subsequently removed and the other was from road construction debris (SS-10). The sampling locations are shown on Figure 7. The results of the analyses are presented in Appendix F.

Surface soil sample SS-10 did not contain any total metal concentrations that exceed the MTCA industrial soil cleanup levels. The sandblast waste materials were found to contain elevated concentrations of metals; however, they will be removed from the site as part of the Port's voluntary "nuisance material" cleanup action.

Subsurface Soils. A total of 15 subsurface soil samples collected from test pits and borings in the General/Fill Area were submitted for chemical analysis. These locations are shown on Figures 5 and 6. Samples were collected from depths ranging from 2 to 9 feet below ground surface. A summary of the soil (both surface and subsurface) analytical results including detection frequencies, statistics, and number of samples exceeding regulatory criteria is presented in Table 9. The results of the soil quality testing include:

- **Metals.** Subsurface total metal concentrations did not exceed MTCA Method A or C industrial soil cleanup levels and are within the range of reference concentrations presented in Table D-1. In addition, as shown in Table L-1, Appendix L, the soil samples in the General Fill Area meet MTCA residential soil cleanup levels.

- ▶ **Volatile Organics.** Carbon disulfide and 2-butanone (MEK) were the only volatile organic compounds detected in General/Fill Area soils. MEK is a common laboratory contaminant and may not actually be present in General/Fill Area soils, although it was not detected in laboratory method blanks. MEK and carbon disulfide concentrations were well below MTCA soil cleanup levels, including the MTCA residential levels.
- ▶ **Semivolatile Organics.** GC-FID screening and semivolatile organic analysis results indicated the presence of hydrocarbons in subsurface soil samples. Di-n-octyl phthalate, a plasticizer and common laboratory/sample handling contaminant, was also detected in one soil sample. However, concentrations of semivolatile organic compounds are well below MTCA industrial and residential soil cleanup levels.

A hydrocarbon-like odor was detected in sample TP-107/S-1, collected at a depth of 2 to 3 feet below ground surface. TP-107/S-1 was excavated in fill containing road construction debris including asphalt and wood. GC-FID screening results indicate the presence of kerosene-range (C10 to C16) hydrocarbons or hydrocarbon-like materials at a concentration of 590 mg/kg. However, no carcinogenic polynuclear aromatic hydrocarbons (cPAHs) were detected and non-carcinogenic PAH concentrations were approximately three orders of magnitude below MTCA soil cleanup levels.

The GC-FID method was used during the first phase of this study to screen for the possible presence of semivolatile organics. Because this GC-FID screening method may also quantify naturally occurring hydrocarbons or hydrocarbon-like materials found in wood and plant materials, it is not a reliable method for quantifying only petroleum-derived hydrocarbons. The limitations and biases of this method will be discussed in greater detail in Subsection 5.2.4.

Although the MTCA soil cleanup levels address the use of total petroleum hydrocarbon (TPH) measures as an initial "screening" to determine the potential for petroleum-related risks, the standards also allow this determination to be made on a chemical-specific basis. For direct soil contact exposures, this demonstration includes an evaluation of BTEX compounds and PAHs, identified as among the most toxic constituents of a variety of petroleum mixtures. Because of the

difficulties in accurately quantifying the hydrocarbon mixtures found on the property and the high potential for positive interferences, we have used BTEX and PAH analyses for evaluation of potential problems.

Sediment Quality - Reichhold S Ditch. Our assessment of the sediment quality within the Reichhold S Ditch is based on six sediment samples collected by Reichhold (CH2M Hill, 1989c). No confirmed detections of organic compounds were reported. Arsenic, copper, lead, molybdenum, and zinc concentrations were reported to be above naturally occurring averages in at least one sediment sample. However, based on the maximum concentrations detected, arsenic is the only metal which exceeds MTCA Method A and Method C industrial soil cleanup levels or the state marine sediment criteria.

Arsenic was detected at concentrations ranging from 23 to 400 mg/kg. Four of the six samples exceeded the state marine sediment criteria of 57 mg/kg and only two samples exceed the MTCA Method A industrial soil cleanup level of 200 mg/kg. The highest arsenic concentrations in the Reichhold S Ditch sediments occur in the central portion of the ditch.

Reichhold suggested that the source of elevated arsenic, copper, lead, and zinc concentrations in the Reichhold S Ditch sediments was possibly from Asarco slag. CH2M Hill (1989c) stated that although the Shallow Aquifer discharges from the Reichhold site into the ditch, much of the elevated metal concentrations were located upgradient of these discharges. It is possible that previous drainage from the OFA/Pennwalt ditch area may have provided a source of arsenic to the Reichhold S Ditch sediment. It is also possible the arsenic was derived from the transport of sandblast grit via runoff from the North Site Area (see Figure 3) to the ditch. It does not appear that the arsenic is currently being transported with surface water from the central part of the ditch as discussed in Subsection 5.3.1 which discusses the surface water quality of the Reichhold S Ditch.

5.2.3 North Site Area

Surface Soils. Three samples of sandblast waste (SS-4, SS-5, and SS-6) were collected from the North Site Area at locations shown on Figure 7. Arsenic, cadmium, chromium, and lead concentrations exceed MTCA industrial soil cleanup levels in at least one of the sandblast waste

samples; however, none of the samples exceed dangerous waste criteria based on extraction procedure toxicity (EP Tox) testing. Results are summarized in Table F-1 in Attachment F-1 of Appendix F. As previously discussed, the sandblast wastes will be removed from the property, disposed of properly, and the soil sampled for confirmation of removal.

Surface soil sample SS-4 was collected in an area of suspected creosote staining. Surface hydrocarbon staining was observed in a relatively small area (less than 10 square feet) and appeared to be limited to the upper three inches of soil. Concentrations of cPAHs in the surface sample exceed the MTCA Method A industrial soil cleanup level of 20 mg/kg.

These surface soil samples are not included in the soil statistical summary tables for the North Site Area as they are currently being removed from the site as described in the Nuisance Material Work Plan (Hart Crowser, 1991b).

Subsurface Soils. A total of 14 subsurface soil samples collected from the North Site Area at depths ranging from 1 to 9 feet below ground surface were submitted for chemical analysis. The sampling locations were selected to broadly characterize the area, focusing primarily on the area to the north that was filled because of difficult access in the wetland area. A summary of the subsurface soil analytical results for the North Site Area is presented in Table 10. The results of the soil quality testing are as follows:

- ▶ **Metals.** Subsurface total metal concentrations were generally elevated relative to area reference concentrations especially in the southwestern portion of the North Site Area. However, mercury is the only metal detected in the North Site Area which exceeds MTCA industrial soil cleanup levels. Mercury exceeds the MTCA Method A level of 1 mg/kg by 1 mg/kg in one sample (TP-116/S-2 at 2 mg/kg). The location of this sample is shown on Figure 18.
- ▶ **Volatile Organics.** None of the volatile organic compounds exceed MTCA industrial soil cleanup levels. However, vinyl chloride, 1,2-dichloroethene, methylene chloride, acetone, and 2-butanone (MEK) were detected in at least one soil sample in the North Site Area. The highest vinyl chloride concentration (0.008 mg/kg) was

detected in boring HC-21. Vinyl chloride was also detected in boring HC-9 (0.007 mg/kg). Methylene chloride, acetone, and MEK are common laboratory and sample handling contaminants and may not actually be present in North Site Area soils. Although they were detected in some method blanks associated with soil analyses conducted as part of this investigation, they were not detected in laboratory method blanks directly associated with these specific samples.

- **Semivolatile Organics.** Carcinogenic and non-carcinogenic PAHs were detected in most of the samples collected in the North Site Area at total concentrations ranging from less than 1 to 28 mg/kg. The highest concentrations were encountered in the southwestern portion of the North Site Area. Total cPAH concentrations in samples TP-115/S-1 (18 mg/kg), TP-114/S-1 (11.4 mg/kg), and HC-21/S-1 (13.7 mg/kg) exceed the MTCA Method C industrial soil cleanup level of 10 mg/kg but do not exceed the Method A soil cleanup level of 20 mg/kg.

No samples exceed MTCA Method A or C industrial soil cleanup levels for cPAHs when adjusted for potency relative to benzo(a)pyrene using toxicity equivalence factors (TEFs). The TEFs used for cPAHs in this report are currently under review by EPA and are summarized in Table H-1 in Appendix H. When these factors are used to adjust for potency, total cPAH concentrations generally decrease because most cPAHs are less toxic than benzo(a)pyrene (Clements and Associates, 1991). Figure 19 shows locations of soil samples exceeding MTCA industrial soil cleanup levels of 10 mg/kg for cPAH. Non-carcinogenic PAH concentrations do not exceed MTCA soil cleanup levels.

The source for the PAHs, elevated mercury, and low levels of volatile organics is unknown. The area is currently undeveloped. Previous activities on or near the property in this area that could possibly explain these occurrences include:

- **Reichhold activities immediately adjacent to this area.** We have limited data describing soil quality in the northeastern portion of the Reichhold facility as this area was not identified as being of any concern (CH2M Hill, 1987a). However, Reichhold has recently removed four former septic tanks in an area just west of the North

Site Area to remove PCB-contaminated soils (Reichhold, 1991) and operated paint sample drying racks in the area adjacent the mercury hit. The chemistry data available for the septic tank removal were not analyzed for PAHs or mercury. No volatile organics were detected in their confirmation sampling.

- ▶ Filling or dumping of excess soils locally by Atochem's predecessors. According to Bodek et al. (1988) "approximately 25 percent of the mercury consumed in the United States is used in the liquid elemental form to make chlorine and caustic using the mercury cell process." According to the hydrogeologic and engineering evaluation of Pennwalt waste management facilities (AWARE, 1981), Atochem uses a diaphragm cell process to produce chlorine and caustic which involves electrolysis of saturated brine solutions and produces only brine muds, asbestos, and residual chlorine as the major waste products. However, mercury has been detected in groundwater in one well at the Atochem facility (AWARE, 1981, and Kennedy/Jenks/Chilton, 1990) so it was possibly used in the past. It is possible residual soils from the main plant construction or other activities may have been placed in this area in the past.
- ▶ It was mentioned during a recent interview with a former Pennwalt Ag-Chem laboratory employee that equipment used during the installation of the Alaska pipeline was stored in the northern portion of the site before being auctioned off. It is possible that cleaning of this equipment on site could result in the release of chlorinated hydrocarbons. It seems unlikely this would be the source of the PAH since this area is not readily accessible by vehicle during the wet season.
- ▶ It is possible the presence of PAHs in the North Site Area is the result of natural processes. PAHs can occur naturally in the environment particularly in soils containing a lot of decaying plant material or where burning of organic materials has occurred (Callahan et al., 1979). Soils adjacent to the marshy area located in the southern portion of the North Site Area contain a large amount of plant remains which may act as a source of PAHs. It is not known if the decay or combustion of these plant materials could result in soil cPAH concentrations exceeding 1 mg/kg.

5.2.4 Ohio Ferro-Alloy (OFA)/Pennwalt Area

Soils. Fifteen surface soil samples were collected within the top 6 inches of soil and 54 subsurface soil samples were collected from test pits and soil borings installed in the OFA/Pennwalt Area. These samples were submitted for the chemical analyses specified in Tables 1 and 2. The subsurface sampling locations are presented on the Boring and Test Pit Location Plans, Figures 5 and 6, respectively. The surface soil sampling locations are shown on Figure 7. A summary of the soil results for this area are presented in Table 11.

Thirteen discrete samples of wood, charcoal, coal, and slag were collected from the OFA/Pennwalt Area to characterize potential contaminant source materials. Results from the chemical testing of these non-soil samples are not included in the OFA/Pennwalt soil summaries but can be found in Table C-3, Appendix C. Geochemical analysis of the slag samples is discussed in Appendix F.

- **Metals.** Subsurface total metal concentrations were generally elevated relative to area concentrations, particularly in the eastern portion of the OFA/Pennwalt Area. OFA operated a chromium and ferrosilicon manufacturing facility in this portion of the site from 1941 to 1974. In addition, Asarco slag occurs scattered in the OFA/Pennwalt Area probably as a result of former log yard operations. We estimate there is approximately 100,000 to 150,000 cubic yards of slag-containing soils in the OFA/Pennwalt Area (See Figure 11 for location of slag-laden fill). Our sampling in this area was generally biased toward samples of soil containing slag.

The highest metal concentrations are associated with fill materials containing OFA slag, ore, or Asarco slag. Arsenic, cadmium, chromium, lead, and mercury exceed MTCA industrial soil cleanup levels in at least one sample. The soil samples collected in the area containing fill/slag material which exceed the MTCA cleanup levels are presented on Figure 18.

No soil samples collected outside of the portion of the OFA/Pennwalt Area containing slag fill exceed MTCA industrial soil cleanup levels for metals. However, slightly elevated concentrations of mercury (relative to reference soil concentrations presented in Table D-1) were detected in samples TP-108/S-2 (1.4 mg/kg) and

HC-10S/S-11 (1.1 mg/kg). Locations of these samples are shown on Figures 5 and 6. Because MTCA cleanup levels are determined to only one significant figure, mercury concentrations less than 1.5 mg/kg technically do not exceed the Method A industrial soil cleanup level of 1 mg/kg.

The source of mercury in the OFA/Pennwalt Area is unknown. Mercury is not generally associated with the slag material and typically does not occur in nature at these concentrations. It is possible that the source of mercury is from Pennwalt (Atochem) operations as discussed in Subsection 5.2.3. although only minor detections of mercury were found on the Atochem site (1.08 mg/kg in sludges which have been removed and 13 ppb in one groundwater sample).

We collected five composite samples to evaluate the leachability of metals from the slag-containing fill material using the TCLP test. We biased the fill composite samples by collecting a higher percentage of slag and ore relative to other soil materials in order to provide a conservative evaluation of metal leachability. Results of the samples analyzed for EP Tox or TCLP metals were well below dangerous waste criteria. Arsenic, barium, copper, lead, nickel, and zinc were the only metals detected in the EP Tox and TCLP leachates (See Table 11).

Leachable arsenic was observed in only 1 of the 13 soils samples analyzed for EP Tox or TCLP metals at a concentration of 0.42 mg/L (SS-TCLP-1). This sample also had the highest total arsenic concentration (240 mg/kg estimated) observed in OFA/Pennwalt Area soils. Of the five composite samples analyzed, sample SS-TCLP-1 contained the highest percentage of Asarco slag relative to OFA slag and ore materials.

Battelle-Northwest conducted leaching tests on the slag fill material from this area to determine the leaching rate of metals from Asarco slag mixed with wood waste. However, the sample used by Battelle to assess the leachability of the slag fill material was not representative of OFA/Pennwalt soils or the OFA slag. Battelle purposely biased the sample by collecting a higher percentage of Asarco slag relative to other soil or OFA slag material to provide worse case conditions. We do not believe that Battelle's leaching

test results can be used to quantitatively evaluate the leachability of slag fill material located in the OFA/Pennwalt Area.

- ▶ **Volatile Organics.** Concentrations of volatile organic compounds do not exceed MTCA industrial soil cleanup standards. Toluene, xylene, and 2-butanone (MEK) were each detected in one soil sample collected in the OFA/Pennwalt Area. As discussed previously, MEK is a common laboratory and sample handling contaminant and may not actually be present in OFA/Pennwalt Area soils. Toluene and xylene are typically associated with petroleum products.
- ▶ **Semivolatile Organics.** GC-FID screening and semivolatile organic analyses indicate the presence of PAHs and dibenzofuran in OFA/Pennwalt Area soil samples. The highest concentrations were detected in an area (approximately 60 by 60 feet in size) near the Pennwalt Ag-Chem facility which contained charcoal briquets (Figure 19). Carcinogenic and non-carcinogenic PAHs in soil samples collected from this area ranged as high as 8,930 and 15,440 mg/kg, respectively. Discrete samples of the charcoal contained carcinogenic and non-carcinogenic PAHs at concentrations ranging as high as 9,500 and 22,000 mg/kg, respectively (Table C-3). PAH concentrations detected in discrete coal and coke samples were several orders of magnitude lower than the concentrations in charcoal samples.

Four samples other than the charcoal exceeded the MTCA industrial soil cleanup level for total cPAHs. Three of these were collected adjacent to the area containing charcoal briquets (SS-104, TP-205/S-2, and TP-206/S-1) and one sample (TP-200/S-1) was obtained from the soil on a timber exhibiting a creosote-like odor. Soils associated with the charcoal and the creosoted timber are the likely cause for the PAHs in these samples. Samples TP-200/S-1 and TP-205/S-1 do not exceed the MTCA Method C soil cleanup level of 10 mg/kg and samples SS-104 and TP-206/S-1 do not exceed the MTCA Method A soil cleanup level of 20 mg/kg when adjusted using toxicity equivalence factors (TEFs). No other samples collected in the OFA/Pennwalt Area exceed MTCA industrial cleanup levels for cPAH or non-carcinogenic PAH. (EPA did a split sample of the soil in the charcoal area. The results are presented in Appendix C.)

EPA method 418.1 analytical results were often lower than the GC-FID screening methods used in this study. For example, the hydrocarbon content in the aged wood chip sample was estimated at 110 mg/kg using the 418.1 method. However, 418.1 results were higher than the GC-FID methods in some other samples containing a high percentage of wood chips or other organic matter.

Based on these results, we have concluded that the GC-FID and 418.1 methods do not provide an accurate estimate of the hydrocarbon content in OFA/Pennwalt Area soils and results from these analyses should not be used for initiating remedial activities. We have used specific compound analyses of volatile organics (including BTEX) and PAHs for determining if soil remedial actions are necessary. The PAH concerns in the OFA/Pennwalt Area were discussed above. No volatile organics were detected at levels above the MTCA soil cleanup levels.

- **Pesticides/PCBs.** Low concentrations (less than 0.2 mg/kg) of three chlorinated pesticide compounds (4,4-DDE, 4,4-DDD, and 4,4-DDT) were detected in sample TP-111/S-1. None of the detected concentrations exceed MTCA industrial soil cleanup standards. Test pit TP-111 was installed adjacent to the northwestern edge of Pennwalt Ag-Chem facility. A pesticide research facility was operated by Pennwalt on the Ag-Chem property. Pesticides were not detected in any of the other soil samples collected along the Pennwalt Ag-Chem fenceline. No PCBs were detected.

Pennwalt Ag-Chem Ditch Sediment. A total of seven discrete and composite samples were collected from the Pennwalt Ag-Chem Ditch at depths ranging from the surface to 3.5 feet. The sampling locations (DS-104 through DS-107) were located as shown on Figure 7. The data are presented in Table C-4, Appendix C and a statistical summary of the data and MTCA comparison are presented in Table 12.

None of the detected metal concentrations exceed MTCA industrial soil cleanup levels although the metal concentrations were generally above the range of soil reference concentrations (Table D-1). Concentrations generally decreased with depth. No pesticides, PCBs, or herbicides were detected in the ditch sediment.

PAHs were detected but were below MTCA industrial soil cleanup levels. The cPAH and non-carcinogenic PAH concentrations ranged up to 2.5 and 3.5 mg/kg, respectively. For comparison, the MTCA Method C residential soil cleanup level for soil is 3.5 mg/kg. The PAH concentrations also generally decrease with depth. Toluene was detected in three of the four samples analyzed. The highest concentration of toluene (0.039 mg/kg) observed in a near-surface sediment sample (DS-106-D) is well below the MTCA industrial soil cleanup level of 40 mg/kg.

The location of the Pennwalt Ag-Chem Ditch approximately corresponds to a former trench or lagoon-like feature which appears in a 1967 photo. The trench is bermed on three sides; the north, south, and west and is open to the Ag-Chem area on the east side. The purpose and use of this feature is unknown at this time. We understand Atochem is currently researching its history (communication with Fred Wolf, December 1991). At a minimum, it is likely to have collected storm water runoff from the Ag-Chem property. These ditch sediment data and the soil data from test pits in this area do not indicate any significant waste disposal into this feature.

OFA Ditch Sediment. Two composite and two discrete sediment samples were collected from the OFA Ditch. Metal concentrations observed in the sediment samples are above the range of expected soil reference concentrations except for mercury and nickel (Table 13). There is no obvious concentration trend with depth. The highest arsenic, copper, lead, and zinc concentrations were detected in the discrete sediment samples (DS-103A and DS-103B). These samples were collected adjacent to an overpass crossing the ditch which appeared to contain a larger percentage of slag materials relative to surrounding soils. Arsenic concentrations in both samples (260 mg/kg) slightly exceed this MTCA industrial soil cleanup level of 200 mg/kg for arsenic. The composite samples did not exceed this MTCA industrial soil cleanup level.

None of the detected semivolatile organic compounds exceed MTCA industrial soil cleanup levels. The constituents, 4-methyl phenol, bis(2-ethylhexyl)phthalate, and PAHs were detected in at least three of the four OFA Ditch sediment samples. There are no clear concentration trends vertically or spatially.

5.3 Surface Water Quality

5.3.1 Pennwalt Ag-Chem Ditch

One surface water sample (SW-1) was collected from the Pennwalt Ag-Chem Ditch in the location shown on Figure 7. Total arsenic (29 $\mu\text{g/L}$), copper (20 $\mu\text{g/L}$), and nickel (31 $\mu\text{g/L}$) concentrations exceed MTCA marine surface water cleanup levels as summarized in Table 14.

However, the ditch is currently sealed off by fill materials and does not discharge to marine environments. The Pennwalt Ag-Chem Ditch is essentially a depression in which water collects during storm or wet season conditions. The ditch does not contain any water during most of the dry season. Water present in this ditch likely infiltrates into the Shallow Aquifer and could potentially impact groundwater quality.

The ditch formerly drained westward to the Reichhold S Ditch (TPCHD, 1988); however, that pathway has been interrupted by fill materials. A predecessor to the ditch was noted as a linear lagoon-type feature in this same area in a 1967 photo. The purpose and use of the ditch is unknown at this time, however, it likely collected surface water runoff from the Pennwalt Ag-Chem area.

5.3.2 OFA Ditch

Three surface water samples were collected from the OFA Ditch (Figure 7). Sample SW-1 was collected in the same location as SW-2 but was sampled in the wet season when the water was ponded above the sides of the ditch. Maximum total arsenic (230 $\mu\text{g/L}$), cadmium (21 $\mu\text{g/L}$), copper (240 $\mu\text{g/L}$), lead (46 $\mu\text{g/L}$), manganese (320 $\mu\text{g/L}$), nickel (15 $\mu\text{g/L}$), and zinc (150 $\mu\text{g/L}$) concentrations exceed MTCA marine surface water cleanup levels (Table 15). Flow in the ditch appeared to be blocked at the time of our wet season sampling. The ditch is largely dry during the dry season.

Metal concentrations were quite variable between the three samples. Total arsenic concentrations in the three surface water samples ranged between 24 and 230 $\mu\text{g/L}$. The highest arsenic concentration was measured during the wet season when the water was pooled above the ditch side walls and flooded a portion of the OFA/Pennwalt Area. We assume that elevated metals concentrations observed in OFA Ditch surface water are due to the presence of slag in the fill materials.

surrounding the ditch, the greater contact area of the pooled water and slag during the wet season, and the stagnancy of the water due to the poor drainage.

Dissolved metal concentrations were measured during the January 1991 surface water sampling event. Arsenic was the only metal which exceeded both the MTCA surface water cleanup levels and the Puyallup River and urban stormwater quality data used for comparisons. This was the sampling period when the highest total metals concentrations were measured. The increased time and area for contact of the water with the slag is probably the cause for the elevated concentrations. Because there was only one sampling for dissolved metals, we recommend additional surface water sampling in this area to confirm the occurrence of dissolved arsenic in OFA Ditch surface waters.

The surface water in this area was previously sampled by Ecology (1985) as part of a log yard study conducted in the tideflats area. We were unable to determine the precise sampling location; however, the map provided in their report shows the location to be in the eastern portion of the OFA/Pennwalt Area. The study focused on trace metals loading to Commencement Bay from log sorting yards and found that Asarco slag used as ballast was the principal cause of the metals loading. The former Cascade Timber Yard No. 2 (located on the eastern arm of the OFA/Pennwalt Area) was one of the sites studied.

Total arsenic concentrations in two surface water samples collected by Ecology as a part of this study ranged from 122 $\mu\text{g/L}$ (measured in 1983) to 4,790 $\mu\text{g/L}$ (measured in 1984). The 1984 sample with the highest total arsenic concentration contained almost 300 times more suspended solids than the 1983 sample or samples collected by Hart Crowser. The extremely high suspended solid content in the 1984 water sample containing 4,790 $\mu\text{g/L}$ of arsenic obviously significantly biases the total metal results.

5.3.3 Reichhold S Ditch

Six surface water samples were collected from the Reichhold S Ditch by CH2M Hill in March 1988 as part of Reichhold's off-site drainageways sediment and surface water investigation (CH2M Hill, 1989c). Formaldehyde was the only organic constituent detected (confirmed) in the surface water samples at concentrations ranging from 63 to 151

$\mu\text{g/L}$. Appendix J, Formaldehyde Analyses Assessment further discusses the occurrence of formaldehyde in the Blair Backup property area.

Average total arsenic ($7.8 \mu\text{g/L}$), copper ($23 \mu\text{g/L}$), nickel ($93 \mu\text{g/L}$), and zinc ($163 \mu\text{g/L}$) concentrations exceed MTCA Method B marine surface water cleanup levels as well as Port groundwater reference concentrations (Table 23). However, the arsenic concentrations (2 to $5 \mu\text{g/L}$), measured in split samples by another laboratory (Battelle) were all within the range of the Port area groundwater reference concentrations.

The source of these elevated metal concentrations may be from groundwater or surface water discharges. At the time of sampling, surface water from the Pennwalt Ag-Chem Ditch was able to discharge into the Reichhold S Ditch. Elevated concentrations of arsenic, copper, nickel, and zinc have been detected in the Pennwalt Ag-Chem Ditch. As discussed previously, the Pennwalt Ag-Chem Ditch is no longer connected to the Reichhold S Ditch and should not currently act as a source of metals to the Reichhold S Ditch. It is not known if any surface water discharges from the Reichhold facility enter the Reichhold S Ditch.

Shallow Aquifer groundwater from both the Reichhold and Blair Backup properties discharge into the Reichhold S Ditch. Based on our comparison of groundwater quality in Shallow Aquifer wells located near both sides of the Reichhold S Ditch, it appears that concentrations of arsenic, copper, nickel, and zinc are typically higher in the Blair Backup property shallow groundwater wells. However, arsenic, copper, and zinc concentrations in at least one of the Reichhold wells bordering the ditch exceed MTCA marine surface water cleanup levels.

We do not believe that surface water discharge from the Reichhold S Ditch will act as a significant source of metals to the Blair Waterway sediments. Nickel and zinc are the only metals which exceed MTCA Method B marine surface water cleanup levels and background conditions as defined by average residential storm water runoff and Puyallup River metal concentrations (Table 20). The flux of these 2 metals to the Lincoln Avenue Ditch and subsequently to the Blair Waterway are likely to be minor given the relatively low flow rate in the ditch and the flow reversals that occur during high tide. The Blair Waterway is not designated as a problem area by the CB/NT Record of

Decision (ROD). In addition, arsenic is the only metal identified as a problem in the Lincoln Avenue Ditch sediments (Landau, 1991).

5.4 Groundwater Quality

The discussion of groundwater quality at the Blair Backup property is divided into three sections:

- ▶ Area groundwater reference concentration data;
- ▶ Shallow Aquifer quality; and
- ▶ Intermediate Aquifer quality.

Within the Shallow Aquifer and Intermediate Aquifer sections we discuss groundwater quality by chemical type (i.e. metals, volatile organics, and semivolatile organics) and discuss the exceedences of the MTCA surface water cleanup levels by area. As discussed in Subsection 5.1.3, the MTCA cleanup levels used for comparison represent the most conservative of the possible cleanup levels that might be appropriate for the site. Generally, where an issue is raised by the MTCA comparison, the data are then compared to other water quality data or criteria to gain perspective on the potential for significant environmental impact.

Summary tables and MTCA cleanup level comparisons of groundwater quality data in the Shallow and Intermediate Aquifers in the General/Fill, North Site, and OFA/Pennwalt Areas are summarized in Tables 17 through 23. The specific data for each of the above areas is presented in Tables C-8, C-9, and C-10 (Appendix C, Volume II) respectively.

5.4.1 Area Groundwater Reference Concentration Data

As part of this investigation, we sampled 10 wells in the Port of Tacoma area, including three wells on the Taylor Way property to establish area groundwater reference values for selected dissolved trace metals and formaldehyde. Reference wells were selected based upon accessibility, location relative to properties of interest, lack of exposure to local industrial activity, and depth of screened interval. The scope of the area groundwater reference study is discussed in Appendix D. The results are presented in Table D-3 in Appendix D.

These area reference data are summarized in Tables 20 and 23 along with Puyallup River water quality data and urban stormwater quality data for comparison purposes.

5.4.2 Shallow Aquifer Quality

The following summaries of the groundwater quality data are based on review of the data generated during three sampling periods (January 1990, October 1990, and December 1990). The December/January data generally represent the wet season conditions and the October data are indicative of the dry season in the Port area. We often refer to average concentration levels within a particular area. This is because the average values better represent the concentration of a potential contaminant being transported with a particular groundwater flowpath toward a receptor (discharge point).

The groundwater quality data for the General/Fill Area, North Site Area, and OFA/Pennwalt Area Shallow Aquifer are summarized in Tables 17 through 19, respectively.

General Groundwater Quality. Groundwater temperatures in the Shallow Aquifer may vary by over 10°C depending on the time of year readings are taken. Temperatures ranged from approximately 7 to 20°C over the course of the two wet seasons and one dry season sampling events.

Groundwater pH ranged from 4.6 (HC-3S) to 11.1 (HC-4). A contour map of pH data collected during the December 1990 sampling event is presented on Figure 20. The highest groundwater pH values were observed in wells located adjacent to the Pennwalt Ag-Chem sodium hydroxide tanks (HC-5, HC-4, HC-11, and EPA-9S) indicating that a release of sodium hydroxide has occurred from the tanks or associated piping. The typical range of groundwater pH in the United States is between 6 and 8 (Hem, 1970).

Total dissolved solids (TDS) concentrations measured during the December 1990 sampling event are contoured on Figure 21. The highest TDS concentrations in the Shallow Aquifer (7,100 and 5,400 ppm) were observed in wells HC-4S and HC-5S located adjacent to the Pennwalt Ag-Chem facility. TDS measurements obtained in January 1990 are very consistent with the December 1990 results. Based on the

USGS dissolved solids classification system (Heath, 1983), groundwater in these wells would be described as fresh to moderately saline. Average TDS concentrations in all three areas exceed the secondary drinking water standard of 500 mg/L.

Dissolved Metals. Dissolved metals were generally detected in at least one of the three site areas except for mercury, molybdenum, selenium, and thallium. Figures 22 and 23 show the distribution of arsenic, chromium, and lead in Shallow Aquifer samples collected during the January and December 1990 sampling rounds, respectively.

The highest arsenic, chromium, and lead concentrations in the Shallow Aquifer were typically observed adjacent to the former Pennwalt Ag-Chem facility and in the northern portion of the North Site Area. These areas ultimately drain to the Hylebos Waterway.

The General/Fill Area generally contained the highest iron, manganese, nickel, and zinc concentrations. The highest concentrations of these metals in the General Fill Area were generally observed in wells HC-2S and HC-13S. The shallow groundwater in this area discharges to the Reichhold S Ditch and eventually ends up in the Blair Waterway.

Comparison between the two wet and one dry season sampling rounds do not show any apparent trends in metal concentrations. Concentrations of arsenic, chromium, and lead measured in selected wells over the three sampling rounds are plotted on Figure 24.

Dissolved metal concentrations (excluding antimony, iron, mercury, molybdenum, selenium, and thallium) exceed MTCA Method B marine surface water cleanup levels in at least one Shallow Aquifer sampling location. Arsenic, copper, manganese, nickel, and zinc are the only metals which exceed MTCA marine surface water levels in more than one of the site areas.

Port of Tacoma groundwater reference concentrations (upper 95th percent confidence limit of mean concentrations) exceed the MTCA marine surface water criteria for several metals including cadmium, copper, manganese, and nickel (See Table 20). Concentrations of these metals in the Shallow Aquifer were generally within the range of values detected in the Port of Tacoma reference samples. Appendix K

provides a specific discussion on the natural occurrence of iron and manganese in groundwater.

We also compared average metal concentrations in each area to regional surface water data including Metro residential (Bellevue) stormwater runoff, the Puyallup River, and the Reichhold S Ditch (See Table 20). The only average metal concentrations that exceeded the MTCA surface water cleanup levels, area reference groundwater concentrations, and these surface water data were arsenic in the North Site and OFA/Pennwalt Areas, and nickel and zinc in the General/Fill Area.

Arsenic and chromium speciation analyses were performed on five groundwater samples collected from the OFA/Pennwalt Area. Chromium speciation results were unusable due to matrix interferences caused by elevated TDS levels in the groundwater samples. Arsenic speciation results indicate that the trivalent form of arsenic accounts for 40 to 85 percent of the total arsenic presentation in the Shallow Aquifer in the OFA/Pennwalt Area. The trivalent form of arsenic (arsenite) is the more toxic form of arsenic and tends to be most prevalent in reducing or oxygen-deficient environments.

Based on our comparison of Shallow Aquifer groundwater quality to MTCA Method B marine surface water metal cleanup levels and regional surface and groundwater quality, we have identified the following issues:

- **Cadmium, Nickel, and Zinc Concentrations in the Central Portion of General/Fill Area.** Nickel and zinc are of more concern than cadmium. The average nickel and zinc concentrations are above both the MTCA marine levels and the area reference values, while the average concentration of cadmium in this area is below both of these criteria. In addition, the well with the highest cadmium detection (HC-13S at 24 $\mu\text{g/L}$) had an undetectable concentration during the first sampling phase. Copper was also detected in the groundwater but at levels well below the area background data.

Concentrations of nickel and zinc decrease significantly as groundwater in the Shallow Aquifer moves from the central portion of the General/Fill Area toward the Reichhold S Ditch. Nickel and zinc concentrations in wells HC-1S and HC-3S (average 43 and 107

and 110 and 210 $\mu\text{g/L}$, respectively) located near the Reichhold S Ditch were at least 2 to 10 times lower than the concentrations observed in samples collected from wells HC-13S and HC-2S (average 455 and 455, and 490 and 300 $\mu\text{g/L}$, respectively).

Sandblast waste is one potential source of cadmium, nickel, and zinc to the General/Fill Area Shallow Aquifer. However, the General/Fill Area has never been developed and metals concentrations in General/Fill Area subsurface soils are within regional background levels. A surface soil sample collected from the area containing road construction debris (SS-10) contained a nickel concentration of 200 mg/kg which exceeds expected soil reference concentrations, although four subsurface soil samples collected from this same area did not contain elevated metal concentrations.

The nature of the fill materials in combination with the geochemical factors may be the cause of increased solubility of these metals. The pH level in Well HC-13S and HC-2S were slightly acidic at 5 and 4.6, respectively. Most metals are more mobile in acidic environments. It is also possible that stronger reducing conditions (oxygen deficient) exist in this area because of the thicker fill deposits and perhaps a greater amount of organic material. Reducing conditions greatly increase the solubility of iron and manganese. Dissolution of iron and manganese oxides releases other metals including cadmium, nickel, and zinc. Well HC-13S contained the highest iron and manganese concentrations in the General/Fill Area and had the thickest section of fill material.

- **Arsenic Concentrations in the Northern Portion of the North Site Area.** The arsenic concentrations in the North Site Area averaged 32 $\mu\text{g/L}$. Arsenic was consistently detected in wells HC-7S and HC-9S at levels which ranged from 32 to 96 $\mu\text{g/L}$.

Potential sources of this relatively low concentration of arsenic to the North Site Area Shallow Aquifer include fill materials deposited along Taylor Way (on or off site), and/or movement of water from within the backfill material surrounding the storm drain beneath Taylor Way toward the Blair Backup property. The Shallow Aquifer Elevation Contour Map (Figure 13) indicates dry season groundwater flow to be from the direction of Taylor Way toward the Blair Backup property. Groundwater with elevated arsenic levels

from either the Atochem or Reichhold site could find a pathway onto the Blair Backup property if this backfill is indeed carrying substantial volumes of groundwater. Both Atochem and Reichhold have detected arsenic in their groundwater monitoring wells along Taylor Way.

- **Arsenic, Chromium, Copper, Lead, and Nickel Concentrations in the OFA/Pennwalt Area.** Although these metals were detected in the OFA/Pennwalt area groundwater above the MTCA Method B surface water cleanup level in at least one well during one sampling event, on an average concentration basis, only arsenic exceeds the MTCA surface water levels, the area reference concentrations, and the regional surface water quality data (See Table 20). We believe a comparison of these data to other water quality data is reasonable given the conservative nature of comparing these interior industrial groundwaters to the MTCA surface water cleanup levels.

The data indicate the primary area of occurrence of the elevated metal concentrations is in three wells around the Pennwalt Ag-Chem fenceline (HC-4S, HC-5S, and EPA 9S), not beneath the OFA slag fill area as might be suspected. This is illustrated by the following table which shows average metal levels for the indicated group of wells. The marine chronic standard and the drinking water standard area are also shown for comparison only.

Metal	Slag Fill Area Avg concentration in $\mu\text{g/L}$ (HC-11S, HC-15S, HC-16S, EPA 7S, EPA 9S)	Ag-Chem Fenceline Area Avg concentration in $\mu\text{g/L}$ (HC-4S, HC-5S, HC-6S)	Marine Chronic Standard in $\mu\text{g/L}$	Drinking Water Standard in $\mu\text{g/L}$
As	25	296	40	50
Cr	39 10 (w/o 9S)	74 111 (HC-4, HC-5 only)	50	100
Cu	29 5(w/o 9S)	29	3	1000
Pb	ND(w/o 9S) 42 (9S only)	26	6	50
Ni	6/ND(w/o 9S) 19 (9S only)	31	8	---

An examination of these data shows that the wells around the Ag-Chem property (HC-4S, HC-5S, and EPA 9S) have the highest concentrations of all the metals detected. Wells HC-11S, HC-15S, HC-16S, and EPA 7S in the heart of the OFA slag fill area have generally undetected metals concentrations (See Table C-10, Appendix C).

The presence of alkaline water adjacent the Pennwalt Ag-Chem facility is the most likely cause for the elevated metal concentrations. It is known that arsenic can become more mobile in alkaline environments particularly under oxidizing conditions (Masscheleyn et al., 1991). Figures 22 and 23 show the approximate extent of the area where arsenic exceeds both the marine chronic standard (40 $\mu\text{g/L}$) and the MTCA Method B surface water cleanup level (2 $\mu\text{g/L}$) used for screening the data.

The alkaline water is likely derived from the Ag-Chem (Wypenn) property. Three above-ground tanks on the Ag-Chem property held sodium hydroxide for many years (they are currently empty) and tank leakage may have contributed to the alkaline waters in this area. Investigations of a former waste pond and stormwater pond

indicated highly alkaline (pH greater than 12) soil and sludges on the Ag-Chem property (AWARE, 1981 and Kennedy/Jenks/Chilton, 1990). The "lagoon" shown on the Blair Backup property in a 1967 photo was used to collect drainage consisting of groundwater. The tanks and/or the waste ponds may have acted as source for high pH waters which were discharged to the lagoon.

Potential sources of these metals include fill materials deposited along Taylor Way, fill materials in the OFA/Pennwalt Area, and/or from an as yet unknown arsenic source on the Ag-Chem property. Atochem is currently remediating arsenic contamination in both soil and groundwater on the main plant property and investigating soil and groundwater quality by the former Ag-Chem facility. It is possible some sodium arsenite from their former herbicide production was disposed of on the Ag-Chem portion of the property. The high pH waters could render generally low arsenic concentrations in soil, sufficiently soluble to cause the elevated concentrations observed in the groundwater in this area.

The slag fill present in the eastern portion of the OFA/Pennwalt Area does not appear to be the primary source of arsenic. Wells HC-11S, HC-15S, HC-16S, and EPA-7S, which are screened in slag fill material, contain relatively low arsenic concentrations. In addition, this is the area of the highest chromium concentrations in soil (See Figure 18), yet the average chromium concentrations in the groundwater is below the MTCA Method B groundwater (surface water) cleanup level. In fact, Well HC-11S is completed in the area of the thickest OFA slag fill and the well is screened within the fill, yet the chromium concentrations in the groundwater do not exceed the MTCA levels.

Volatile Organic Compounds. Several volatile organic compounds were detected in the Blair Backup property Shallow Aquifer including vinyl chloride, dichloroethene, trichloroethene, acetone, and BTEX compounds. Of these, only vinyl chloride and benzene exceed MTCA Method B marine surface water cleanup levels. The distribution of vinyl chloride and BTEX compounds at each sampling location is presented on Figure 25 and discussed below.

- **Vinyl Chloride in Shallow Aquifer in the North Site Area.** Vinyl chloride was detected in all ten Shallow Aquifer groundwater

samples collected in the North Site Area with a maximum concentration of 85 $\mu\text{g/L}$ in well HC-7S. Vinyl chloride concentrations exceed the MTCA marine surface water level of 2.9 $\mu\text{g/L}$ in all of the samples. However, the concentrations appear to be decreasing with time as shown on Figure 26. Vinyl chloride and 1,2-dichloroethene were detected at very low concentrations in several soil samples collected from the North Site Area.

The groundwater flow patterns in the area of the vinyl chloride occurrence vary with the season. During the wet season much of the flow is directed from the Reichhold property area through the northern North Site Area toward Taylor Way (See Figure 12). However, during the dry season the flow in the area appears to be directed away from Taylor Way toward the interior of the North Site Area where the wetland occurs (See Figure 13). These changing flow directions slow the transport of the vinyl chloride and ultimate discharge to a potential receptor.

Potential sources include past releases from the Reichhold Septic Tank Area or from historical vehicle maintenance activities which may have occurred on the property. Groundwater in the Reichhold Septic Tank Area generally flows from the Reichhold property onto the North Site Area. During the removal of the four septic tanks, Reichhold sampled soils for volatile organics (including chlorinated solvents and vinyl chloride). Although no chlorinated solvents or vinyl chloride were detected in soils remaining in the Septic Tank Area, we do not have any data on the levels of contaminants in the excavated soils. Vinyl chloride has not been detected in the well located between the Reichhold Septic Tank Area and the North Site Area wells. It is possible that a former release would have migrated beyond the Reichhold property boundary. Vinyl chloride is a breakdown product of commonly used chlorinated solvents including tri- and tetrachloroethene.

- **Benzene Detected in Shallow Aquifer in OFA/Pennwalt Area has Dissipated.** Benzene was detected in eight Shallow Aquifer samples collected from the OFA/Pennwalt Area. Benzene is typically associated with petroleum products. Only one sample exceeded the MTCA marine surface water cleanup level of 43 $\mu\text{g/L}$ for benzene. This elevated concentration of benzene occurred in well HC-4S during the January 1990 sampling round; however, subsequent sampling at this location revealed concentrations below the MTCA

marine surface water level. This apparent decrease in concentration appears to be a general trend for benzene as shown on Figure 26.

Formaldehyde. Formaldehyde was detected in 20 of the 23 Shallow Aquifer groundwater samples collected during the December 1990 sampling event. There does not appear to be any defined distribution of formaldehyde, although the highest concentrations were observed adjacent to the Pennwalt Ag-Chem facility and in the vicinity of well HC-13S. Formaldehyde was also detected in wells located on the Pennwalt Ag-Chem facility property at concentrations ranging from 210 to 1,670 $\mu\text{g/L}$ (Boateng and Associates, 1990). However, the laboratory used the Hantzsch method which we believe is unsuitable for analysis of groundwater samples with high turbidity and organic contents. Appendix J presents more discussion of the laboratory analyses of formaldehyde.

Of the 20 positive detections of formaldehyde on the Blair Backup property, only four samples (HC-5S, HC-12S, HC-13S, and EPA-9S) exceed the range of formaldehyde concentrations encountered in the Port of Tacoma groundwater reference samples (<5 to 60 $\mu\text{g/L}$). The highest formaldehyde concentration (260 $\mu\text{g/L}$) was observed in sample HC-13S. We do not have sufficient toxicological data to establish a MTCA surface water cleanup level for formaldehyde.

No known major anthropogenic sources of formaldehyde exist on the Blair Backup property. Formaldehyde was handled at the Reichhold facility as recently as 1985 to 1986 and has been detected in groundwater samples collected from this site at concentrations ranging from 60 to 440 $\mu\text{g/L}$. However, it is unlikely that formaldehyde has migrated from the Reichhold site to the Blair Backup property Shallow Aquifer because:

- ▶ The Reichhold S Ditch intercepts most of the shallow groundwater flowing from the Reichhold facility; and
- ▶ The highest formaldehyde concentrations were detected in the central and northern portions of the site and not in the area adjacent to Reichhold.

The source of formaldehyde (if actually present) to the Blair Backup property and Port of Tacoma shallow groundwater sampled during our investigations is unknown. While it is possible that Reichhold operations could have released some formaldehyde to the Blair Backup property via groundwater transport or potential dumping of formaldehyde-containing materials, it is extremely unlikely that Reichhold operations could be responsible for formaldehyde concentrations detected in the East-West Road and Taylor Way properties as well as the Port of Tacoma background areas.

It is possible that there is a natural or global source of formaldehyde to the area or that the analytical method is actually quantifying some other material as formaldehyde. Potential natural sources of formaldehyde include forest fires, animal wastes, microbial products, and plant remains (Howard, 1990). In addition, combustion processes such as automobile emissions are major sources of formaldehyde to the atmosphere. Because formaldehyde is highly soluble in water, it will be washed out of the atmosphere with rainfall and may eventually be incorporated into groundwater.

Degradation of organic matter associated with the tideflats and the log sorting operations may also act as a widespread source of formaldehyde to the Port area. The presence of high levels of organic materials in groundwater also increases the likelihood for analytical matrix interferences resulting in the quantitation of other materials as formaldehyde. Regardless of whether these formaldehyde concentrations are derived from natural or global sources or are due to analytical interferences, we do not believe that remedial action based on the presence of formaldehyde is feasible or appropriate at the Blair Backup property.

Semivolatile Organic Compounds. PAH compounds were the predominant semivolatile organic compounds detected in the Shallow Aquifer. Bis(2-ethylhexyl)phthalate (BEHP), phenol, 4-methylphenol, and benzoic acid were also detected in at least one sampling location. BEHP and cPAH concentrations were the only semivolatile compounds which exceed the MTCA marine surface water cleanup levels used for groundwater data screening.

BEHP was detected in six of the 38 Shallow Aquifer samples collected on the Blair Backup property. BEHP, which is commonly used as a plasticizer, is often introduced to samples during sample handling as well as in the analytical laboratory. We do not believe the presence of BEHP in Shallow Aquifer samples is of concern due to the lack of consistent detections in wells sampled during the three sampling rounds and the presence of BEHP in several method and field blanks associated with the sampling events (see Appendix B - Data Validation Report and Appendix C - Summary Tables).

PAH compounds were detected in the North Site Area and adjacent to the Pennwalt Ag-Chem facility as shown on Figure 25. Carcinogenic PAH (cPAH) concentrations exceed the MTCA Method B marine surface water cleanup level of 0.02 $\mu\text{g/L}$ in 15 of the 37 samples collected in the North Site and OFA/Pennwalt Areas.

Elevated cPAH concentrations may be related to suspended sediments present in Shallow Aquifer wells. The highest cPAH concentrations were generally detected during the dry season sampling round in wells located in or adjacent to areas containing elevated soil cPAH concentrations. Because of the lower water levels encountered during the dry season, groundwater samples collected during this time interval were often more turbid and contained higher levels of total suspended solids than the wet season samples. Because cPAH compounds have very low aqueous solubilities and tend to adsorb onto soil matrices, cPAHs detected in groundwater are probably derived from suspended soil particles.

We believe it is unlikely that cPAH compounds present in the Shallow Aquifer will migrate off site to marine surface water bodies. The cPAHs were not leachable in soil samples containing the highest cPAH concentrations based on TCLP testing.

Chlorinated Herbicides in OFA/Pennwalt Area. Three samples taken from wells HC-4S, HC-5S, and EPA-9S near the Pennwalt Ag-Chem facility were analyzed for chlorinated herbicides. Dinoseb was detected in all three samples with concentrations ranging from 2 to 5 $\mu\text{g/L}$ with the maximum occurring in well HC-4S. Well EPA-9S also contained 9 $\mu\text{g/L}$ of 2,4-DB. We do not have sufficient toxicity data to establish a cleanup level for dinoseb or 2,4-DB. However, a To-Be-Considered level of 7 $\mu\text{g/L}$ for dinoseb has been proposed as part of the Phase V

Drinking Water Regulations to be promulgated in 1992. Our data did not exceed this proposed level.

These chlorinated herbicides likely exist in groundwater as the result of activities at the Pennwalt Ag-Chem facility. Pennwalt historically produced agricultural pesticides and herbicides.

5.4.3 Intermediate Aquifer Quality

Groundwater quality in the General/Fill Area and OFA/Pennwalt Area Intermediate Aquifer is summarized and compared to MTCA groundwater cleanup levels in Tables 21 and 22. The specific results for each well are presented in Tables C-8, and C-10 in Appendix C with groundwater data for the General Fill and OFA/Pennwalt Areas, respectively. Groundwater flow directions in the Intermediate Aquifer are depicted on Figures 15 and 16.

General Groundwater Quality. Temperatures in the Intermediate Aquifer ranged from 8 to 19°C over the year. Measurements of pH ranged from 5.8 to 7.5 which is within the typical range for groundwater in the United States.

The Intermediate Aquifer is in hydraulic connection with the adjacent waterways which allows for mixing of groundwater with saline water. The mixing results in high total dissolved solids (TDS) concentrations in the Intermediate Aquifer. Figure 27 presents a contour map of the TDS levels measured in the Intermediate Aquifer. TDS concentrations were found to be generally greater than 10,000 µg/L over most of the site, which exceeds the MTCA requirements for drinking water sources.

Metals. In general, the metals were undetected or at low concentrations within the Intermediate Aquifer. Copper, lead, manganese, silver, and zinc slightly exceeded the MTCA marine surface water levels in a few samples during one sampling event; however, the same metal was generally undetected during subsequent sampling and analysis for the same metal from the same well. For reference, we compared average metal concentrations within the Intermediate Aquifer in each area to regional surface water and groundwater quality data (Table 23). We use average values because we believe they better represent the concentration of a potential contaminant being transported within a particular groundwater flowpath. Based on the

comparison presented in Table 23 we do not believe the metal exceedences are significant for the following reasons:

- ▶ Manganese and copper concentrations are within the range of Port of Tacoma groundwater reference concentrations;
- ▶ Silver was detected in only one sample (HC-14I) at an estimated concentration ($5\text{ }\mu\text{g/L}$) which only slightly exceeds the MTCA marine surface water criteria of $2.3\text{ }\mu\text{g/L}$;
- ▶ Three samples contained elevated lead concentrations (HC-17I at $6.4\text{ }\mu\text{g/L}$, HC-4I at $50\text{ }\mu\text{g/L}$, and MW-29I at $6.8\text{ }\mu\text{g/L}$) which were above the MTCA surface water cleanup levels of $5.6\text{ }\mu\text{g/L}$. However, these values were relatively low and these same wells had samples which tested below the MTCA marine surface water cleanup levels during the latest round of sampling; and
- ▶ Zinc slightly exceeded MTCA marine surface water level in only four of the 44 samples analyzed (HC-2I at $90\text{ }\mu\text{g/L}$, HC-14I at $94\text{B }\mu\text{g/L}$, HC-4I at $160\text{B }\mu\text{g/L}$, and HC-6I at $87\text{B }\mu\text{g/L}$). Results in three of these samples were probably positively biased due to the presence of zinc in method blanks associated with the samples (indicated by a B adjacent the reported value). Zinc concentrations measured at the other sampling location (HC-2I) exceeded MTCA marine surface water cleanup level during the first sampling round but was below the cleanup level during the latest round of sampling.

Volatile Organic Compounds. Acetone and toluene were the only volatile organic compounds detected in the Intermediate Aquifer. Both of these constituents are common laboratory contaminants and were not consistently detected in the same locations during the three sampling rounds. Concentrations of these compounds were well below MTCA marine surface water cleanup levels.

Formaldehyde. Formaldehyde was detected in seven out of the 20 groundwater samples collected in the Intermediate Aquifer. Only two sampling locations (HC-13I and HC-12I) contained formaldehyde concentrations which exceed the MTCA marine surface water cleanup standard of $21.6\text{ }\mu\text{g/L}$. Both of the detected formaldehyde concentrations were within the range of values (<5 to $60\text{ }\mu\text{g/L}$) detected in Port of Tacoma reference samples.

Semivolatile Organic Compounds. PAHs, BEHP, and dibenzofuran were detected in the Intermediate Aquifer. Carcinogenic PAHs and BEHP were the only constituents which exceed MTCA marine surface water cleanup levels. BEHP was detected in less than 20 percent of the samples collected. We do not believe that the concentrations of BEHP observed in the Intermediate Aquifer is of concern due to the lack of consistent detections in wells sampled during the three sampling rounds and the presence of BEHP in several method and field blanks associated with the sampling events.

The cPAH concentrations detected in wells HC-4I ($<1 \mu\text{g/L}$) and EPA-8I ($6.2 \mu\text{g/L}$) exceed the MTCA marine surface water level of $0.02 \mu\text{g/L}$. PAHs were also detected in well EPA-8I by Ecology and Environment as part of their 1987 investigation of the former Cascade No. 2 log sorting yard (Ecology and Environment, 1987). These wells are located in or adjacent to areas containing elevated soil cPAH concentrations so the possibility of sediment in the water sample may account for the PAH detection. As discussed previously, cPAH compounds are relatively immobile and will not migrate off site to marine surface water bodies.

5.5 Alexander Avenue Strip Area

Reichhold established three waste disposal areas in the Alexander Avenue Strip Area in the 1960s and 1970s (CH2M Hill, 1988a). Reichhold's evaluations of these areas indicated that remedial action of soils was required on only one of the three areas (solid waste management unit [SWMU] 49). Elevated concentrations of pentachlorophenol and PCBs were detected in SWMU 49 soils and subsequent soil removal was undertaken (CH2M Hill, 1989h). The soil removal was completed at SWMU 49 (CH2M Hill, 1991a and EPA and Ecology, 1990).

We reviewed the Reichhold Precorrective Action Groundwater Monitoring Results from July 1990, October 1990, and January 1991. This monitoring program is being conducted pursuant to Reichhold's RCRA Corrective Action and Storage Permit (Permit Number WAD 009252891). Of the required groundwater monitoring parameters, only formaldehyde was consistently detected and quantified at concentrations above MTCA Method B marine surface water cleanup levels. Monitoring wells where formaldehyde was detected above this level

(21.6 ppb) included MW-28S, MW-29S, MW-39I, MW-50I, and MW-54I. Other constituents detected and quantified included 4(1,1-dimethylethyl) phenol (MW-33S), PCB 1248 (MW-43S), as well as several chlorinated pesticides (including Beta-BHC, Heptachlor, Aldrin, Dieldrin, 4,4'-DDE, Endrin, and others), and metals (July 1990 analyses only).

We understand that the results of the Precorrective Action Groundwater Monitoring Program are under review within the framework of Reichhold's RCRA permit. The detection of certain required monitoring parameters and other constituents (PCB, phenols, pesticides, and metals) indicates a need for ongoing monitoring of this area.

5.6 Summary of Soil, Sediment, and Water Quality Issues

We have identified several issues of potential concern based on our screening of the soil and water quality data. MTCA cleanup levels were the primary tools used to identify issues of potential concern. For soils and some sediments we used the MTCA Methods A and C Industrial soil cleanup levels. For groundwater we used the MTCA Method B surface water cleanup levels.

The MTCA Method B surface water cleanup levels are a very conservative tool for evaluating the groundwater data considering the highly industrial use of the surrounding area, the poor natural water quality, and the limited nature of the Shallow Aquifer in which some contaminants were found. In addition the distance that the site is removed from the waterways, the principal environmental receptor, will minimize the potential for environmental impact because processes such as adsorption, precipitation, dispersion, and dilution will tend to reduce metal concentrations in groundwater as it migrates away from the source areas.

To further assist in determining the environmental concerns associated with the property we compared the groundwater data to area reference concentrations (See Tables 20 and 23) and reviewed historical information to identify potential sources. Based on these comparisons and considerations presented above, the issues of potential concern are summarized.

5.6.1 Soil and Sediment Quality

- ▶ Arsenic concentrations detected in four sediment samples collected in the Reichhold S Ditch were above the marine sediment levels of 57 mg/kg. Arsenic concentrations in the ditch samples ranged from 23 to 400 mg/kg. It is unlikely these sediments would be transported to the waterways at concentrations high enough to exceed the marine standard because of the dilution by surface water. Surface water transport is the primary mechanism for the sediment transport and arsenic was low to undetected in the surface water sampling of the Reichhold S Ditch (CH2M Hill, 1989c).

The source of the arsenic was probably Asarco slag or sandblast grit present on either the Reichhold or Blair Backup properties. In either case, it appears the slag source is no longer available for discharge to the ditch since Reichhold has removed their only known Asarco slag fill and surface water runoff from the OFA/Pennwalt Area to the ditch no longer occurs.

- ▶ Mercury exceeded the MTCA industrial cleanup level of 1 mg/kg in one sample (at 2 mg/kg) collected in a north-central location within the North Site Area (TP-116, Figure 18).
- ▶ Carcinogenic PAHs were also detected in the North Site Area (Figure 19) but were not in exceedence of the MTCA Method A cleanup level of 20 mg/kg or the Method C cleanup level of 10 mg/kg when adjusted for potency using toxicity effect factors. The source of these contaminants is unknown but may be related to Reichhold activities which potentially have extended into this area in the past.
- ▶ Arsenic, cadmium, chromium, lead, and mercury in soil and sediment samples collected in the former OFA site exceed MTCA industrial soil cleanup levels for at least one metal (See Figure 18).
- Slag and ore present in the OFA/Pennwalt Area are the likely source of these metals. TCLP testing of the slag indicates these soils do not leach metals at dangerous waste levels. Wells completed in the slag fill or just beneath it also indicate that the slag does not significantly leach metals without a catalyst such as high pH waters.

- ▶ Carcinogenic PAH concentrations in several OFA/Pennwalt Area soil samples exceed MTCA industrial soil cleanup levels. All except for three of these soil samples were from within the area of buried charcoal briquets (see Figure 19). One of the other samples was of soil obtained adjacent to a creosoted timber. The two remaining soil samples were taken near the charcoal so may have contained soils associated with the charcoal deposit.

5.6.2 Surface Water Quality

- ▶ Elevated concentrations of arsenic and several other metals were detected in OFA Ditch surface water. The highest levels were observed during the wet season when the ditch was blocked and the water pooled and was stagnant over a large area in contact with the slag. It is likely slag was used to support ditch construction. There was a roadway over the ditch in the area of our highest arsenic concentrations and slag could be seen lining this overpass.
- ▶ Nickel and zinc concentrations in the Reichhold S Ditch exceed MTCA surface water cleanup levels and reference concentrations. It appears these metals may be from groundwater discharging to the ditch from the General Fill Area. It is unknown if these metals are impacting the Blair Waterway.

5.6.3 Groundwater Quality

- ▶ Nickel and zinc concentrations in wells HC-13S, HC-1S, HC-2S, and HC-3S in the General/Fill Area Shallow Aquifer exceed MTCA marine surface water cleanup levels as well as reference concentrations and regional surface water quality data. It appears these metals are migrating with groundwater toward the Reichhold S Ditch and discharging to the ditch.
- ▶ Arsenic, chromium, copper, lead, and nickel concentrations in the OFA/Pennwalt Shallow Area Aquifer have exceeded the MTCA marine surface water cleanup levels in at least one well during at least one sampling event (See Figures 22 and 23). The exceedences all fall around the Ag-Chem fenceline or along Taylor Way as shown on the figures. We suspect this is due to the high pH levels and/or migration of these metals through advection and dispersion from groundwaters beneath the Ag-Chem area and Taylor Way.

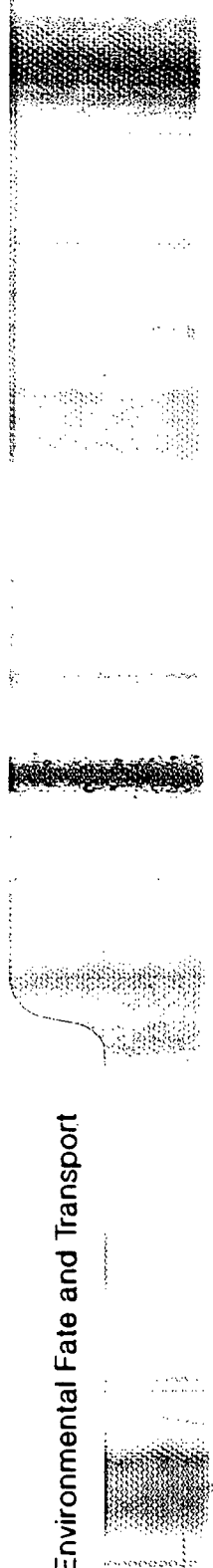
Only arsenic also exceeds the stormwater runoff, Puyallup River, and area reference water quality when we compare average metal concentration levels in the OFA/Pennwalt Area to these data (See Table 20). Arsenic also exceeds the MTCA cleanup level in several shallow North Site Area wells around Taylor Way (See Figures 22 and 23).

- ▶ Vinyl chloride concentrations detected in the North Site Area Shallow Aquifer exceed MTCA marine surface water cleanup levels (See Figure 25). Concentrations of vinyl chloride appear to be decreasing with time and are not likely to cause significant environmental or human health impacts.
- ▶ Formaldehyde concentrations in four Shallow Aquifer wells exceed the range of Port of Tacoma reference concentrations as well as MTCA marine surface water cleanup levels. It is not known if the RCRA method used to analyze for formaldehyde is actually measuring free formaldehyde or some other organic materials or if this occurrence may be natural to the area conditions. There is no apparent on-site source for this constituent.
- ▶ Elevated cPAH concentrations were detected in 4 wells in the OFA/Pennwalt Area (HC-4S, HC-5S, HC-11S, and EPA 9S) and in 3 wells in the North Site Area (HC-8S, HC-9S, and HC-21S). These cPAH compounds are probably associated with suspended solids in the wells and are very unlikely to migrate off the property to surface water bodies. Wells downgradient of the areas where PAHs were detected did not contain any PAHs.
- ▶ Low concentrations (2 to 9 $\mu\text{g/L}$) of chlorinated herbicides were detected in three shallow wells (HC-3S, HC-4S, and EPA 9S) located adjacent to the Pennwalt Ag-Chem facility.
- ▶ Carcinogenic PAHs detected in two Intermediate Aquifer wells (HC-4I and EPA-8I) exceed the MTCA marine surface water cleanup level of 0.02 $\mu\text{g/L}$. These cPAH compounds may be related to sediment carried down during drilling and are unlikely to migrate off the property to surface water bodies.

- Formaldehyde concentrations detected in Alexander Avenue Strip Area groundwater samples exceed MTCA marine surface water cleanup levels. The presence of other constituents (PCBs, phenols, pesticides, and metals) indicates a need to continue to monitor this area. The Shallow Aquifer Interceptor Drain installed by Reichhold will help remediate the shallow groundwater in this area once it is in full operation.

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6.0 Environmental Fate and Transport



6.0 ENVIRONMENTAL FATE AND TRANSPORT

This section describes the general physical and chemical properties of chemicals of concern and their potential migration pathways. The chemicals of concern were selected based on their frequency of detection and exceedence of area reference concentrations and/or MTCA screening levels as discussed in the previous section. To assess the impacts of the chemicals identified on human health and the environment, we discuss the processes that may alter the chemicals as they move through the environment to the Hylebos and Blair Waterways.

6.1 *Environmental Fate of Chemicals of Concern*

The environmental fate of chemicals of concern is dependent on a number of processes including solubility, complexation, precipitation, and volatilization. This section describes the processes that affect the chemicals identified on the Blair Backup property and the common nature of their occurrence.

Arsenic. Speciation of arsenic plays an important role in its environmental fate and is a function primarily of its oxidation state. Arsenic is relatively mobile in aquatic environments; however, arsenic is strongly sorbed onto soils and sediments resulting in its partial removal from solution. Because of the mobility of arsenic, there is some potential for migration in groundwater.

Chromium. Chromium exists in either trivalent (Cr+III) or hexavalent (Cr+VI) forms. The hexavalent form of chromium is quite soluble and does not significantly sorb to clays or hydrous metal oxides; however, it is strongly sorbed by organic matter. Trivalent chromium readily forms insoluble chromium hydroxide, and thus, precipitation is thought to be the dominant environmental fate of chromium in natural waters (Hart Crowser, 1992).

Copper. Copper is ubiquitous in the environment. It is very persistent in both water and soil. Several processes determine the fate of copper in aquatic environments including complexing with humic substances, sorption to hydrous metal oxides, clays and organic material, and bioaccumulation. The environmental behavior of copper in soil/water is

dependent upon pH, inorganic colloids, and ion-exchange characteristics of soils.

Lead. Like other metals, lead is widespread in the environment as a result of its natural occurrence and use in various common products. However, lead typically is not very soluble in water. Concentrations of lead are reduced by sorption and also by precipitation in highly contaminated areas, although sorption is the dominant process. Lead has a tendency to complex with organic materials which increases its adsorptive affinity for clays.

Nickel. Nickel, which exists predominantly in a divalent state, is one of the most mobile of heavy metals in aquatic systems. Sorption of nickel by hydrous iron and manganese oxides probably has the most, although limited, control over its mobility. Humic acids increase the solubility of nickel to the point where it is unlikely that precipitation is a significant fate in water.

Zinc. Zinc is commonly present in both soil and water matrices due to its natural occurrence and use in numerous man-made products. The solubility and mobility of zinc is dependent on pH, redox potential, temperature, and the presence of other constituents. Because zinc tends to adsorb onto iron and manganese oxides as well as clay minerals, its mobility in the environment is limited.

cPAHs. Existing data indicate that cPAHs are relatively insoluble in water and tend to adsorb to suspended particulates in water. Thus, sediment movement is the most likely transport mechanism for cPAHs. The small amounts that do dissolve will likely be degraded by photolysis and, to a lesser extent, by oxidation. The ultimate fate of cPAHs is probably biodegradation and biotransformation.

Vinyl Chloride. The fate of vinyl chloride in the environment is generally transport to the atmosphere through volatilization and subsequent photooxidation. Vinyl chloride is fairly water-soluble and tends to be weakly adsorbed to soils, thus making it persistent in groundwater. Vinyl chloride is not readily biodegraded.

6.2 Migration Pathways in Water

Both surface water and groundwater are important media for the movement of chemicals of concern on the Blair Backup property to off-site receptors, the Blair and Hylebos Waterways. Figure 4 shows the principal surface water routes and Figures 12 through 17 show the groundwater flow directions in both the Shallow and Intermediate Aquifers. The pathways followed by site groundwaters are discussed below.

6.2.1 Shallow Aquifer

Three pathways have been identified for water associated with the Shallow Aquifer.

- ▶ Flow toward Taylor Way with possible discharge to the backfill material around subsurface utility conduits;
- ▶ Flow toward and discharge to Reichhold S Ditch; and
- ▶ Flow downward into the Intermediate Aquifer.

Each pathway begins with the downward movement of surface water through the soil column to the water table. During the wet season, most of this recharge is from ponded water that is the result of the poor site drainage. Although little ponding occurs during the dry season, heavy precipitation events may provide sufficient water for infiltration before evaporation takes place.

Once the downward moving water has entered the groundwater flow system, it will follow one of the three primary pathways. In the eastern and southeastern areas of the site, groundwater flows toward Taylor Way, possibly due to the influence of sand and gravel backfill material surrounding the subsurface water main and stormwater drain along the road (Figure 4). As groundwater encounters the backfill, it likely flows preferentially through this more permeable material. Groundwater could then move northeast or southwest along Taylor Way within the backfill, eventually discharging to Lincoln Avenue Ditch or the Kaiser Ditch which discharge to the Hylebos Waterway. Groundwater not captured by the backfill would likely flow toward and mix with groundwater beneath the Atochem facility.

The second pathway in the Shallow Aquifer involves water in the General/Fill Area and to the west of the groundwater divide that exists in the North Site and OFA/Pennwalt Areas. Groundwater in the General/Fill Area flows toward and discharges to the Reichhold S Ditch. From the North Site and OFA/Pennwalt Areas groundwater takes a less direct route to the Reichhold S Ditch. As discussed in Subsection 4.4.2, groundwater from these areas moves toward and may discharge to a wet area located in the west North Site Area. The fine-grained nature of the soils in this area may act as a sponge to soak up this groundwater and slowly release it as discharge to the Reichhold S Ditch.

Water in the Reichhold S Ditch flows westward toward Alexander Avenue into a subsurface drain that directs the water to the northwest. The water eventually discharges to the Blair Waterway.

The downward movement of water through the Upper Aquitard and into the Intermediate Aquifer is the final pathway for water in the Shallow Aquifer. Although the Upper Aquitard is considerably less permeable than the surrounding aquifers, high vertical gradients between the aquifers at some locations indicate that downward-vertical flow to the Intermediate Aquifer may make up a substantial portion of the discharge from the Shallow Aquifer.

6.2.2 Intermediate Aquifer

The principal pathways for groundwater flow in the Intermediate Aquifer appear to be toward the waterways and potentially downward to the Deep Aquifer. Water level data indicate there is some component of flow toward the waterways; however, tidal influences cause gradient reversals in the Intermediate Aquifer, thus net flow rates toward the waterways are likely to be small. There also appears to be a groundwater sink in the central area of the site with groundwater flowing in this direction. In this area the intermediate aquifer may be discharging to the "Deep Aquifer" of the Reichhold investigation.

Reichhold data suggest that some downward flow between the Intermediate and Deep Aquifers occurs but that gradient reversals due to the tides limit the amount of downward discharge.

6.3 Fate and Transport of the Chemicals of Concern

This section discusses possible scenarios for the eventual fate of chemicals identified to be of concern on the Blair Backup property. For each chemical of concern, a pathway, based on spatial distribution of that chemical, is suggested and processes that may occur are described.

6.3.1 Trace Metals

Concentrations of trace metals present in the Shallow or Intermediate Aquifers will likely decrease significantly as they migrate away from source areas via the following processes:

- ▶ Adsorption onto soil matrices — particularly onto clays, iron and manganese oxides, and organic materials.
- ▶ Precipitation with iron and manganese oxides due to changing redox conditions. Groundwater in the North Site and OFA/Pennwalt Areas are fairly oxygen-deficient or reduced due to the presence of abundant organic materials. Iron and manganese oxides are fairly soluble under these conditions. As groundwater migrates off the property and becomes more oxygenated, iron and manganese precipitate and pull other metals out of solution.
- ▶ Dispersion and dilution with off-site waters.

Numerous other factors such as complexation and changes in groundwater pH and salinity will also affect the concentrations of metals reaching surface water receptors.

Metal Transport to Reichhold S Ditch. Surface water data collected from the Reichhold S Ditch (CH2M Hill, 1989d) indicate that the ditch has contained nickel and zinc at concentrations exceeding MTCA marine surface water cleanup levels. Arsenic and copper have also been detected in surface water samples at concentrations above the marine surface water criteria but the arsenic was not detected in a split sample suggesting a very transient nature or laboratory error, and copper levels do not exceed Puyallup River, residential stormwater runoff or area reference concentrations levels (See Table 20).

Groundwater and surface water discharges from both the Reichhold and Blair Backup properties probably contribute metals to the Reichhold S Ditch. Nickel and zinc are considerably elevated in the Shallow Aquifer in the General/Fill Area. However, the existing data show that attenuation of the highest nickel and zinc concentrations occurs as the shallow groundwater moves from the central General/Fill Area toward the Reichhold S Ditch. This is exhibited by comparison of average nickel and zinc concentrations at HC-13S which is in the central General/Fill Area with HC-1S and HC-3S which are downgradient of HC-13S and adjacent the Reichhold S Ditch. Average nickel and zinc concentrations in HC-13S are 490 and 230 $\mu\text{g/L}$, respectively. These levels are reduced to between <20 and 110 $\mu\text{g/L}$ for nickel and between 75 and 210 $\mu\text{g/L}$ in HC-1S and HC-3S, respectively. Arsenic and copper were undetected in the downgradient wells during at least one of the sampling rounds.

Mass fluxes of arsenic, copper, nickel, and zinc from the Blair Backup property Shallow Aquifer to the Reichhold S Ditch are presented in Table 24. Most of the arsenic discharging from the Blair Backup property Shallow Aquifer to the Reichhold S Ditch is derived from the OFA/Pennwalt Area, whereas most of the copper, nickel, and zinc appears to come from the General/Fill Area. The overall flux of these metals to the Reichhold S Ditch ranged from 0.08 (copper) to 0.75 (zinc) pounds per day (Table 24). For reference, estimated mass fluxes of these metals in the Taylor Way storm drain and Puyallup River ranged from 80 (nickel) to 780 (zinc) and 65,000 (arsenic) to 1,250,000 (zinc) pounds per day, respectively.

During at least part of the year (dry season) groundwater from the North Site Area and a portion of the northwestern OFA/Pennwalt Area appears to flow toward the wetland located in the southern part of the North Site Area. At this time, low concentrations of trace metals (tens of ppb) and vinyl chloride (average level of 36 ppb) may be migrating with the groundwater toward the wetland. Pentec (1992) evaluated the potential for impact on the existing wetland from groundwater discharges. They concluded that the low concentrations are unlikely to impact the wetland based on a comparison of the identified concentrations in groundwater with typical urban stormwater runoff quality. In addition, the wetland was found to be highly disturbed, filled, and young in nature with no endangered, threatened, or sensitive species. The wetland is believed to drain to the Reichhold S Ditch.

Water in the Reichhold S Ditch empties into the Lincoln Ditch and eventually discharges to the Blair Waterway. It is unlikely that there is a significant contribution of metals to the Blair Waterway from the Reichhold S Ditch related to groundwater and surface water discharges from the Blair Backup property. Substantial dilution with other waters in the Lincoln Avenue Ditch would likely occur and the tidal influences limit the amount of discharge from the ditch.

Metal Transport toward Taylor Way. Groundwater flowing toward Taylor Way is likely to discharge to the backfill around the Taylor Way storm drain or mix with groundwater beneath the Atochem facility. If the waters discharge to the stormdrain backfill they would be diluted by water flowing through the backfill which would include groundwater discharges from other properties located along Taylor Way, such as Atochem and Reichhold.

Rates of dilution were estimated for flow through the Taylor Way storm drain system. We estimate that 3 to 7 gpm of groundwater may be discharging to the storm drain backfill from the surrounding Atochem and Reichhold properties. Using discharge estimates of 0.33 gpm from the OFA/Pennwalt Area and 0.2 gpm from the North Site Area, the Blair Backup property groundwater would be diluted by a factor of between 4 and 18 times. Our assumptions included:

- ▶ The Atochem site discharges groundwater at a rate similar to the Blair Backup discharges (0.5 to 1 gpm);
- ▶ Reichhold data on the Shallow Aquifer flow on their eastern property (2 to 6 gpm); and
- ▶ Flow in the drain backfill from upgradient of the site of 0.5 gpm.

If we use the average arsenic concentration for the entire OFA/Pennwalt Area of 127 $\mu\text{g/L}$, and assume a ten-fold dilution, then the arsenic concentration in groundwater discharged to the backfill would be reduced to about 12 $\mu\text{g/L}$ before it enters the Lincoln Avenue Ditch or the Kaiser Ditch. Additional dilution and dispersion would occur in these surface water drainage bodies before the groundwater reaches the Hylebos Waterway.

The area of the highest arsenic concentration is found around HC-5S and HC-6S in the northern portion of the OFA/Pennwalt area. In this area, the average arsenic level is 296 ug/L (See table in Subsection 5.4.2). Even at this higher concentration level, a ten-fold dilution of the arsenic concentration from the north OFA/Pennwalt Area would reduce the metals concentration to below roughly 30 ug/L before discharge to the Lincoln Avenue Ditch or the Kaiser Ditch. Additional dilution would occur before ultimate discharge to the Hylebos Waterway.

With these dilutions the arsenic concentrations will be below the Ecology cleanup standards for arsenic beneath the Atochem facility (1,000 $\mu\text{g/L}$) and the 3009 Taylor Way property (40 $\mu\text{g/L}$) adjacent the Kaiser Ditch. The arsenic cleanup standard for the Atochem facility is approved by Ecology under a Clean Water Act Consent Decree and the Ecology-approved cleanup standard for the 3009 Taylor Way site is out for public comment under MTCA. The Blair Backup property groundwater would discharge to and/or mix with these groundwaters prior to discharge to the Hylebos Waterway.

If the groundwaters do not discharge to the subsurface drain backfill then the groundwater would pass through and mix with groundwaters beneath the Atochem main plant facility. The groundwater extraction system installed to cleanup arsenic in groundwater beneath the Atochem facility would likely capture Blair Backup property groundwaters which move into this area.

Other attenuation mechanisms such as adsorption onto soil matrices, precipitation, and dispersion will further decrease metal concentrations before the groundwater discharges to the Hylebos Waterway.

6.3.2 Organics

Carcinogenic PAHs. As discussed previously, cPAHs are relatively immobile in groundwater systems due to their low aqueous solubilities and their tendency to absorb onto soil matrices. Based on the groundwater quality data collected to date, it appears that little or no migration of cPAHs from source areas has occurred. We believe it is unlikely that cPAH compounds present in the Shallow Aquifer will migrate off site to marine surface water bodies. If cPAH compounds are able to migrate off site, they would be diluted by off-site waters in a manner similar to that discussed for metals.

Vinyl Chloride. Vinyl chloride in the shallow groundwater is confined to the North Site Area (Figure 25). Because it is weakly sorbed onto soils, groundwater will be the primary media in which it exists. During the dry season, the primary direction of groundwater flow is toward the wetland in the south North Site area with eventual discharge to the Reichhold S Ditch.

These organic contaminants are likely to be rapidly degraded upon reaching the wetland. The concentrations of the organics is not high enough to be of biological concern because in general ppb concentrations are not considered a threat to the biological integrity of a wetland ecosystem (Pentec, 1991). It is unlikely the vinyl chloride will ever reach the Reichhold S Ditch; however, if it did it would be rapidly volatilized and ultimately photooxidized. Vinyl chloride was not detected in Reichhold S Ditch surface water samples.

Vinyl chloride concentrations in groundwater flowing toward the Taylor Way storm drain would decrease by approximately one order of magnitude before reaching the Hylebos Waterway (see discussion in **Metal Transport to Taylor Way Storm Drain Backfill** subsection) due to dilution with off-site water. A ten-fold dilution reduces the average concentration of the wet season discharges of 36 ug/L to about 3.6 ug/L, which is close to the marine surface water level of 3.4 ug/L. The concentration of this chemical will be further reduced by volatilization losses before reaching surface waters. Thus groundwater is not a probable source to the Hylebos Waterway.

The seasonal reversals observed in the groundwater flow direction will reduce the net transport rate of the vinyl chloride toward either receptor.

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7.0 HUMAN HEALTH RISK EVALUATION

This section evaluates the baseline human health risks associated with current uses of the Blair Backup property, as well as future risks associated with potential future commercial and industrial use of the property. The focus of the risk assessment is to identify potential human exposures that would require cleanup of the site.

As defined by EPA (1989), a baseline risk assessment is an analysis of the potential adverse health effects (current and future) caused by hazardous substance releases from a site in the absence of any actions to control or mitigate those releases. The baseline risk assessment builds directly upon and contributes to the site characterization, and serves as a basis to develop, as necessary, recommendations for appropriate remedial response alternatives.

It should be noted that this baseline risk assessment has been conducted using generally conservative assumptions according to guidelines outlined by EPA Region 10 (1990 and 1991). The purpose of using health-conservative assumptions is to define the potential for adverse health effects using conditions that tend to overestimate risk. The final health risk estimates will generally be near, or higher than, the upper end of the range of actual exposures and associated risks. As a result, this risk assessment should not be construed as presenting an absolute estimate of potential risk to human health. Rather, it is a conservative analysis intended to indicate the potential for adverse impact to occur.

This section provides an overview of the risk assessment including the general approach and conclusions. The limitations of this risk assessment are discussed in Section 7.1. In Section 7.2, the chemicals considered most likely to pose a health risk (the chemicals of potential concern) are identified. Section 7.3 presents the general approach to human exposure and Section 7.4 summarizes the results of the risk assessment. To improve readability of the overall report, the details of this risk assessment are provided in Appendix G. In Appendix G, exposure pathways of potential concern are identified and procedures used to calculate doses to exposed populations via each significant exposure pathway are discussed. A toxicity assessment for the chemicals of concern is presented in Appendix G. Transport models used to estimate concentrations of contaminants in air and surface water are also described in Appendix G. Appendix G presents the

estimated doses and risks for each pathway, and presents an evaluation of multipathway risks along with a discussion of the uncertainties in the risk assessment.

7.1 Limitations of the Risk Evaluation

This risk evaluation assesses baseline human health risks associated with current uses of the Blair Backup property, as well as those risks associated with future commercial or industrial use of the property. It is assumed that the property will not be used in the future for residential purposes. The scope of the site investigation of the Blair Backup property is limited to characterizing the distribution of chemicals in soil and groundwater on the property itself and does not extend to areas beyond the property boundary where chemicals may have originated or been transported. Therefore, evaluation of potential off-site exposures as a result of groundwater or surface water migration were evaluated only to the extent that this was possible using existing data collected from the Blair Backup property.

Although initially this risk assessment was completed prior to the federal EPA issuing default risk assessment factors, we revised the RME risk to be consistent with recently established EPA Region 10 risk assessment factors. However, since under the industrial scenario, EPA Region 10 has not developed average risk assessment factors, the average is based on previous, more conservative EPA Region 10 assumptions; thus the average risk presented herein generally represents an over-estimate relative to the RME risk.

7.2 Identification of Chemicals of Potential Concern

Chemicals of potential concern were determined on the basis of analytical results of samples collected from the Blair Backup property. Statistical summaries (frequencies of detection, average and maximum concentrations, and the upper 95th percentile confidence limit [95% CL] of the mean) for all detected chemicals in soils, groundwater, surface water, and sediments are summarized in Tables 9 through 15, 17 through 19, 21, and 22. Selection of chemicals of potential concern was based on a two-step process. First, statistical results of soil and groundwater sampling were compared with area reference samples. Next, a MTCA screening and a risk screening were conducted on soil, sediment, and groundwater samples to identify those constituents

contributing to 95 percent of the site risk. Table 25 summarizes the selection of chemicals of potential concern detailed in the following paragraphs.

Inorganics detected in soils were compared to area soil reference concentrations as discussed in Subsection 5.2.1. Inorganic chemicals which were detected in any sample at a concentration greater than the 95th percentile concentration in the area reference samples from that medium were retained for further evaluation in the risk assessment. Based on this comparison, the inorganics listed in Table 25 were present at elevated concentrations.

Inorganics that were not detected at elevated concentrations in soils compared to area reference soil concentrations were copper, nickel, and zinc.

Chemicals were selected as chemicals of potential concern for the risk assessment if they exceeded MTCA cleanup levels for soils or groundwater, as shown in Table 25.

In addition, a toxicity concentration procedure recommended by EPA (1989) was used to ensure that the selected chemicals represent at least 95% of the total carcinogenic or non-carcinogenic hazard from all chemicals detected in a given medium and subarea of the site (e.g., North Site Area groundwater). All chemicals that are considered known (Group A) human carcinogens were included as chemicals of potential concern regardless of their concentration or frequency of detection.

A number of chemicals were detected at the Blair Backup property for which no toxicity criteria currently are available. Most of these are low toxicity, (magnesium, chloride, and sulfate) or are necessary components of the human diet (calcium). However, two inorganic chemicals with known toxic effects, iron and lead, were detected above area reference concentrations in soil and/or groundwater. EPA (1990) has concluded that toxicity data on iron are inadequate for quantitative risk assessment. Since this chemical is unlikely to be toxic at levels encountered in the environment, iron will not be considered an indicator for the Blair Backup property. Lead is of concern for neurobehavioral effects on children and is considered a probable human carcinogen; however, EPA has not developed toxicity criteria for

exposure to lead. Lead will be considered as an indicator chemical but will be discussed only qualitatively in this report.

Chemicals that were identified as of potential concern in one medium (e.g., groundwater) were also selected as indicators for all other media in which they were detected, in order to account for cumulative risks from multiple exposure pathways. Thus, although copper, nickel, and zinc were eliminated from consideration based on area reference soil concentrations, they were evaluated in the risk assessment due to detection in other media. Similarly, one inorganic metal, molybdenum, was eliminated from consideration in the risk assessment since it was only detected in one media infrequently (detected only in one soil sample). Chemicals selected for further evaluation in the risk assessment are listed in Table 25.

Another constituent eliminated from further consideration in the risk assessment was formaldehyde due to the lack of a suitable analytical method to provide sufficient certainty in media concentrations (refer to Appendix J for details).

Although chemicals of potential concern were identified for the property as a whole, certain chemicals were only detected in individual subareas of the property. Thus, risk assessment for the subareas of the property was conducted for only those constituents of concern detected in that subarea.

Also, for those constituents without toxicity factors for inhalation pathways, only the oral routes of exposure were evaluated in the risk assessment. Thus, the constituents of potential concern evaluated in each area of the property varies depending on the exposure pathway (see Appendix G tables).

7.3 Human Exposure Assessment

7.3.1 Potentially Exposed Populations

As discussed in Section 2.0, the Blair Backup property is an undeveloped parcel situated in an industrial area between the Hylebos and Blair Waterways. The property is comprised of an irregularly shaped area bordered on three sides by industrial facilities operated by Reichhold Chemical, Atochem, and Kaiser Aluminum, and on the

fourth side by Alexander Avenue, and a narrow rectangular area bordering on Alexander Avenue (Alexander Avenue Strip Area). The Alexander Avenue Strip Area is currently undergoing remediation by Reichhold Chemical as part of the ongoing remediation efforts on their property and will not be evaluated in this risk assessment.

The Blair Backup property is fenced on the sides bordering the public roads but the fence is not secure and could allow public access. Access from the adjoining industrial properties is unrestricted. In the past, debris and wastes were dumped on the site, indicating occasional unauthorized access to the property. The Hylebos and Blair Waterways lie approximately 800 feet northeast and southwest of the property, respectively. The nearest residential area is located about 4,000 feet southeast of the site in the Town of Fife. A second residential area is situated on a 300-foot bluff on the far side of Blair Waterway, approximately 4,000 feet northeast of the site.

The potential for future exposures to indicator chemicals depends on assumptions of future land use. It is assumed for this risk assessment that future use of the Blair Backup property will be limited to industrial uses. This assumption is reasonable given the industrial uses of the surrounding properties and restrictions imposed by the Tribal Agreement. If future industrial facility development occurs, the population most likely to be exposed to indicator chemicals at the site would be workers at the Blair Backup property.

7.3.2 Identification of Exposure Pathways

A complete exposure pathway is necessary to link chemicals of potential concern identified at a site with the potentially exposed populations (EPA, 1989). An exposure pathway is considered complete if there is: (1) a source and mechanism of chemical release from a source; (2) a mechanism by which chemicals can be transported from the source to the receptor; (3) an exposure point where contact can occur; and (4) an exposure route (e.g., ingestion) by which contact can occur. If these four conditions are not met, the pathway is considered incomplete and should not be considered in a baseline risk assessment.

The pathways considered for possible evaluation in this risk assessment are:

- ▶ Dermal contact with soil;
- ▶ Soil ingestion;
- ▶ Fugitive dust inhalation from soil releases;
- ▶ Vapor inhalation from soil and groundwater releases;
- ▶ Ingestion of contaminated foods;
- ▶ Dermal contact with surface water and sediments; and
- ▶ Consumption of groundwater.

Based on an initial evaluation of possible exposure routes, pathways were excluded from further consideration if they failed to meet one or more of four conditions for a complete pathway. The basis for inclusion or rejection of the pathways for quantitative exposure assessment is summarized in Table 26 and is discussed in the following text.

7.3.3 Current-Use Exposure Pathways

Individuals entering the Blair Backup property could be exposed to indicator chemicals in soils, surface water, and sediment via dermal contact and incidental ingestion of soils, by inhalation of fugitive dusts, or by inhalation of vapors.

Under current land use conditions, populations most likely to contact on-site media are:

- 1) Trespassers entering the site from public roads or adjacent industrial facilities; and
- 2) Workers engaged in hazardous waste remediation activities on adjoining properties.

Exposures to individuals engaged in hazardous waste site remediation are regulated under OSHA and will not be evaluated in this risk assessment. The likelihood of the general public trespassing on the property is very low due to the entirely industrial character of the area. The frequency of exposure of trespassers entering the site from adjacent properties is also expected to be low. There is a high degree of uncertainty in attempting to evaluate the behavior of persons trespassing on the site, potential risks to this population will be

discussed qualitatively based on comparison to risks for populations that are more likely to be exposed (i.e., future workers on the property).

In addition to exposures to individuals on the property, off-site transport of contaminated dust or vapors in air could pose a source of exposure to workers in the adjoining industrial facilities. Exposures to area residents from airborne contaminants is expected to be substantially less than potential worker exposure due to the distance (4,000 feet) from the site to the nearest residential neighborhoods. Exposures to workers in adjacent industrial facilities from inhalation of airborne dusts or vapors is a potentially complete pathway and will be evaluated in the risk assessment. The primary source of volatile organic compounds (VOCs) that could reach off-site populations is the Shallow Aquifer. VOCs generally were not detected in soils.

No water supply wells are located on the Blair Backup property. Therefore, there is no current route by which exposure to on-site groundwater could occur and groundwater ingestion will not be evaluated as a current-use pathway.

No food crops or livestock are raised on the Blair Backup property. There is therefore no route by which human food chain exposures could occur on the site and these pathways will not be evaluated as a current-use pathway.

7.3.4 Future Industrial/Commercial Use Exposure Pathways

If the property were developed in the future for commercial or industrial use, the development would likely involve some degree of soil grading, excavation, and paving. Future exposures would depend on the depth to which excavation occurs, the extent to which the land surface is covered by paving or other cover, and the type of structure placed on the site. For the purposes of this assessment, it will be assumed that future site development will involve construction of a commercial or industrial facility, and that the land surface outside the building will remain unpaved.

Chemicals of potential concern were identified in soils in three areas of the site. Populations most likely to contact surface soils are workers at a future commercial or industrial facility. Contact with subsurface soils

is expected to be limited to workers exposed during construction of a future facility, and during repair and maintenance work.

Inhalation of organic compounds volatilizing from the shallow on-site groundwater and inhalation of fugitive dusts released from surface soils by wind erosion are potentially complete pathways for future on-site workers and were evaluated.

Groundwater from the Shallow Aquifer or Intermediate Aquifer is not likely to be used as a water supply source for a future industrial or commercial facility at the site, since the shallow water-bearing zones do not provide sufficient yield for these purposes. In addition, area reference concentrations of manganese and dissolved solids in the vicinity of the site exceed secondary drinking water standards (USGS, 1987), further reducing the suitability of these shallow groundwaters for consumption. Use of the groundwater for commercial or industrial purposes is therefore unlikely and ingestion of on-site groundwater will not be evaluated as a future-use exposure pathway.

Exposure to surface water and sediments are potentially complete pathways for future on-site workers, if maintenance activities necessitate contact with ditches. However, concentrations of the indicator chemicals in surface water are generally much lower than in sediments, and surface water is not likely to remain in contact with the skin for as long a time as for sediments. Potential risks associated with surface water contact are therefore likely to be lower than those for contact with sediments, thus, sediment contact will be evaluated in this report. Potential risks from direct contact and incidental ingestion of sediments will be evaluated for future workers. It should be noted that contaminants in the ditches bordering the property include contributions from adjacent industrial facilities.

7.3.5 Exposures to Contaminants Transported Off Site in Surface Water or Groundwater

Migration of chemicals of potential concern beyond the site boundaries in groundwater or surface water could result in exposures to off-site populations. Off-site exposures will be estimated in this risk assessment to the extent possible using existing information.

Based on the hydrogeologic flow patterns described in Section 4.0, groundwater in some areas of the Blair Backup property could migrate beyond the property boundaries and act as a source of off-site contamination. Groundwater from the Shallow Aquifer discharges into ditches bordering the property, which in turn discharge into the Blair and Hylebos Waterways. Groundwater in the Intermediate Aquifer also discharges into the waterways. Chemicals of potential concern entering the waterways could be concentrated in the tissues of fish or other aquatic organisms, which may then act as a source of exposure to area residents who rely on local fish and shellfish as part of their diet.

Shallow or intermediate groundwater is not used for a drinking water supply in the areas between the Blair Backup property and the Blair and Hylebos Waterways. Thus, ingestion of groundwater by workers in adjacent facilities is not a complete pathway under current conditions. Future use of the off-site groundwater for a water supply is not likely due to the quality of the water and low yield of the Shallow and Intermediate Aquifers.

7.3.6 Summary of Exposure Pathways

The basis of selection of exposure pathways for further consideration in the risk assessment is summarized in Table 26. Pathways that will be quantitatively evaluated in this risk assessment are:

Potential Current-Use Exposure Pathways

- ▶ Inhalation by off-site workers of fugitive dusts released from surface soil.
- ▶ Inhalation by off-site workers of vapors emitted from on-site groundwater.

Potential Future Commercial/Industrial Use Exposure Pathways

- ▶ Dermal contact with and incidental ingestion of soil by future workers.
- ▶ Inhalation by future workers of volatile organic compounds emitted from on-site groundwater.

- ▶ Inhalation by future workers of fugitive dusts released from surface soils.
- ▶ Dermal contact with and incidental ingestion of sediment.

Potential Off-Site Exposure Pathways

- ▶ Ingestion of fish from Blair and Hylebos Waterways.

7.4 Human Health Risk Evaluation Summary and Conclusions

This risk evaluation was conducted to determine the potential human health risks associated with chemicals in soils, sediment, groundwater, and surface water at the Blair Backup property. Areas of concern were identified on the property based on chemical quality of various media as discussed in Section 2.2. Investigations at the site have indicated the presence of chemicals of potential concern to human health including vinyl chloride, benzene, arsenic, nickel, and hexavalent chromium, which are classified by EPA as known human carcinogens. In addition, bis(2-ethylhexyl)phthalate, certain polycyclic aromatic hydrocarbons, beryllium, cadmium, and lead have been identified at the site and are classified as probable human carcinogens. Other chemicals of potential concern at the site have been shown to cause systemic toxicity under certain exposure conditions.

7.4.1 Summary of Carcinogenic and Non-Carcinogenic Risks

Upper-bound lifetime excess cancer risk and Hazard Indices associated with potential current and future exposures at the Blair Backup property and those associated with potential exposures from off-site migration of contaminated groundwater are summarized in Table 27. A summary of potential multipathway risks is provided in Table 28.

7.4.2 Evaluation of Human Health Effects from Exposure to Lead

Elevated concentrations of lead were detected in soils, sediments, and shallow and intermediate groundwater from the OFA/Pennwalt Area. Therefore, current and future populations contacting these media may be exposed to lead in dust, by direct contact with soils and sediments, and through ingestion of fish from Blair and Hylebos Waterways.

Acceptable daily intakes for exposure to lead were not developed by EPA (1984b) because the general population is already accruing unavoidable background exposures through food, water, and dust. EPA considers that any significant increase above background exposure would represent a source for concern. EPA (1990) concluded that it is "considered inappropriate to develop a reference dose for inorganic lead". However, currently EPA recommends the use of a 500 mg/kg cleanup level for residential site use and a 1,000 mg/kg cleanup level for industrial site use (CDC, 1986).

The primary risk for exposure to lead is to young children, due to neurobehavioral effects that have been observed at extremely low blood lead levels. Since the planned future use of the site is for an industrial facility, and the primary land uses in the vicinity are industrial, it is not expected that children would be present on the site. However, if the property were converted to a retail commercial use, it is possible that children would occasionally be present. In that case, the children could be at risk of adverse effects from contact with site soils and inhalation of dusts. Since children in urban areas often exhibit blood lead levels in excess of the EPA exposure guidelines (Glass, 1984), additional sources of ambient lead exposure are of concern.

Since the Blair Backup property is intended primarily for industrial use, we think that an average site concentration of 1,000 mg/kg lead is sufficiently protective. Concentrations exceeding 1,000 mg/kg lead are present in sandblast wastes of the General/Fill Area and the North Site Area which have been removed as part of the land transfer agreement. Although the maximum concentration of lead detected in the OFA/Pennwalt Area exceeds 1,000 mg/kg (1,100 mg/kg), the average and upper 95th lead concentrations in the area equal 106 and 156 mg/kg, respectively, which are sufficiently protective of residential site use according to current EPA guidance.

7.4.3 Current Site Use

Estimated total potential excess cancer risks (10^{-7} to 10^{-9}) were below the range of risks that EPA considers as an appropriate target for remedial action (10^{-6} to 10^{-4}) for all current use scenarios. The calculated Hazard Indices for total non-carcinogenic effects did not exceed unity for any scenario. In addition, calculated multipathway

exposures were well below EPA target risks. The current site use risks were also well below current MTCA target risks.

7.4.4 Future Commercial or Industrial Site Uses

Estimated total potential excess cancer risks exceeded the range of risks that EPA considers as an appropriate target for remedial action (10^{-6} to 10^{-4}) for the following future-use scenarios:

- ▶ Direct contact by future on-site workers with soils in the OFA/Pennwalt Area for the RME risk, assuming that no charcoal is removed during source removal activities.

If samples from discrete areas of charcoal within the OFA/Pennwalt Area are not included in the risk assessment (which is representative of a currently proposed interim source removal action), RME risks would fall below 10^{-4} . The residual cancer risk from direct contact with soils in the OFA/Pennwalt Area if charcoal materials are removed, would be primarily due to arsenic.

The Hazard Indices for total non-carcinogenic effects exceeded unity for average and RME dust inhalation scenarios for future workers in the OFA/Pennwalt Area, and were associated with chromium.

For future use scenarios, multipathway risks were calculated for future workers in each area of the property. Estimated multipathway excess cancer risks exceeded the EPA target risk range in the OFA/Pennwalt Area under average and RME conditions assuming no charcoal source removal action. If charcoal source removal is conducted, the RME risks no longer exceed the EPA target risk range. The Hazard Indices exceed unity in the OFA/Pennwalt Area as discussed above for dust inhalation associated with chromium.

This risk assessment evaluated cPAHs using toxicity equivalence factors (TEFs), following the steps and using the factors shown in Appendix H and Table H-1, respectively. However, since the use of TEFs is currently under EPA review, for completeness, we also conducted the risk assessment using total cPAHs (without using TEFs). The following briefly summarizes the differences in the carcinogenic risk results using total cPAHs (as detailed in Table H-2 in Appendix H).

Upper-bound lifetime cancer risks calculated using total cPAH concentrations (rather than TEF-corrected cPAH concentrations) resulted in slightly higher risks (e.g., 7×10^{-6} changes to 2×10^{-5} under the future use scenario for dust inhalation in the OFA/Pennwalt Area under RME exposure conditions). Use of total cPAHs rather than TEFs did not change the number of scenarios in which risks exceed the 10^{-4} target level.

7.4.5 Off-Site Migration of Groundwater

Evaluation of the migration of contaminated groundwater off of the Blair Backup property was beyond the scope of this project; however, this migration may lead to increased exposures to off-site populations from contact with surface water or marine organisms from the Blair or Hylebos Waterway. Risks associated with groundwater transport were addressed in this risk assessment to the extent that hydrogeological evaluation of off-site groundwater transport could be supported by existing information. Sufficient information was available to make a reasonable assumption that groundwater in the Shallow Aquifer discharges into ditches which discharge to the Hylebos and Blair Waterways, but does not indicate whether chemicals originating on the site have in fact reached these waterways. In addition, this risk evaluation did not take into account contaminants discharged into ditches from adjacent facilities, or contaminants taken up by fish that originate in other areas of the waterways.

Risks to area residents consuming fish from the Hylebos and Blair Waterways did not exceed a 10^{-6} excess cancer risk or a Hazard Index of one for either the average or RME scenarios.

8.0 Conclusions and Recommendation

8.0 CONCLUSIONS AND RECOMMENDATIONS

Past land uses on the Blair Backup property and activities on adjacent properties have impacted environmental quality on the property. Relative to contamination on adjacent properties, concerns identified on this property comprise only a minor portion of overall human health and environmental concerns in the area. Some of the concerns have been remediated as summarized below. However, there are a few potential hazards identified which should be considered for remedial action.

The cleanup actions which have already occurred on the property or are in progress include:

- ▶ Reichhold Chemicals Inc. has completed cleanup of PCB-contaminated soils from RCRA SWMU 49 in the Alexander Avenue Strip Area of the Blair Backup property. They have installed a groundwater extraction system in the Intermediate Aquifer to cleanup contaminated groundwater that has migrated onto a portion of the Blair Backup property. A shallow interceptor drain installed on the boundary between the Reichhold property and the Alexander Avenue Strip parcel will also collect Shallow Aquifer groundwater in the Alexander Avenue Strip Area for treatment.
- ▶ Kaiser Aluminum & Chemical has completed sludge and associated soil removal from the wet scrubber pond sludge area located partially on the Blair Backup property.
- ▶ The Port has completed an underground storage tank and associated soil removal in the former truck wash area.
- ▶ The Port is currently removing various debris piles and materials illegally dumped or left on site. These "nuisance materials" which include sandblast grit, drums containing oily materials, asbestos wallboard and pipe, small patches of oily stained soil and construction debris are being tested for appropriate disposition. Underlying soils will be tested and soil removal accomplished until testing verifies the cleanup is completed.

These cleanup actions were conducted under the review and approval of the jurisdictional state and/or federal agency so are considered to be complete and to meet state and federal contamination law in general accordance with the terms of the Memorandum of Agreement regarding implementation of the Puyallup Settlement Agreement. Cleanup actions on the Blair Backup property were and are being conducted by Reichhold pursuant to offsite corrective action requirements as part of their EPA RCRA permit. Cleanup actions were conducted by Kaiser on the Blair Backup property according to a Department of Ecology Consent Decree under the Washington Model Toxics Control Act (MTCA). Cleanup of nuisance material was conducted by the Port of Tacoma consistent with voluntary cleanup provisions under MTCA subject to final review by EPA, Ecology, and the Tribe.

Remaining issues at the site are discussed below. Based on our sampling and analysis, screening of the data with MTCA cleanup levels and area reference concentration data, and assessment of human health and environmental risks we believe that the property is suitable for commercial/industrial development if these issues are addressed. The soil concerns identified relate to future human health risks through inhalation and direct contact under industrial exposure scenarios.

Groundwater quality is of concern where it affects surface waters into which it ultimately discharges. The potential for environmental impacts from site groundwaters are addressed through an assessment of off-site transport of identified constituents of concern. A summary of the concerns, our conclusions about their potential impact to human health or the environment and the specific actions recommended is discussed. Figure 28 presents the location of areas discussed below which are identified for additional action.

8.1 OFA/Pennwalt Area - Metals and PAHs

Soil and groundwater quality concerns related to metals and PAHs were identified in the OFA/Pennwalt Area. The principal concern is the elevated PAHs associated with charcoal and an apparently small amount of construction debris including a few timbers coated with a creosote-like material. Of less concern are elevated metal levels associated with the slag fill. Arsenic and chromium were identified at levels which may potentially present a human health risk as defined by MTCA (10^{-5} potential excess cancer risk), however, these metals do not

exceed the EPA (CERCLA) target risk of a 10^{-4} potential excess cancer risk. Arsenic is probably associated with Asarco slag which is scattered throughout the area and/or related to former Atochem use of portions of the site and the adjacent property. Chromium is most likely associated with OFA slag located throughout the former OFA-occupied area.

Charcoal-Related PAHs

The primary human health risk identified for future industrial use at the Blair Backup property is due to charcoal-related PAHs. Under a lifetime exposure scenario for a future site worker, a potential excess cancer risk of 3×10^{-5} (average case) and 6×10^{-4} (Reasonable Maximum Exposure [RME] case) were estimated. The PAHs identified above MTCA industrial soil cleanup levels in this area were around the buried charcoal. If the visually identifiable charcoal is removed, the potential excess cancer risk falls to between 3×10^{-6} and 3×10^{-5} (See Table 27). The occurrence of cPAHs outside of the charcoal area appears to be related to a few creosoted timbers and associated construction debris. Only one of the locations containing buried railroad timbers and debris had a PAH concentration approaching the MTCA industrial soil cleanup levels.

PAHs have been found in groundwater in the areas where they were found in soils in the OFA/Pennwalt Area. We believe the PAHs in the groundwater are at least partially related to particulate matter in the water samples. Because the PAHs were detected in wells immediately surrounding the charcoal area, the "hot spots" of charcoal and timbers are the likely source for the elevated concentrations observed. These constituents are unlikely to migrate far so present limited environmental impact. PAHs have not been detected in groundwater sampled from wells hydraulically downgradient of those wells around the area of charcoal occurrence where the PAHs in groundwater were measured.

Chromium

Chromium present in the Ohio Ferro-Alloy slag presents a minor potential for risk to human health through inhalation of dust particles, depending on site use and the resulting exposures. The estimated lifetime excess cancer risk for a future site worker is 4×10^{-6} for the average case and 2×10^{-5} for the RME case using EPA Region 10

assumptions. Given the conservative nature of these assumptions we believe the average case may be more representative of future site use. Data indicate the chromium is not currently leaching into groundwater at levels above MTCA marine criteria nor creating surface water and sediment discharge concerns.

Arsenic

Arsenic potentially poses a minor human health risk through direct contact and ingestion of on-site soils. The potential risk identified from long-term human exposure to existing conditions is between 2×10^{-6} (average case) and 3×10^{-5} (RME case). In addition there is potential environmental impact to surface waters via runoff to the OFA Ditch and potential surface water and sediment transport from the OFA Ditch to the Kaiser Ditch and on to the Hylebos Waterway. Arsenic exceeding MTCA cleanup levels has been measured in both the sediment and surface waters of the OFA ditch. Metals loading to the Hylebos Waterway is of concern as arsenic is identified as a priority chemical for the Head of the Hylebos remedial action as referenced in the Commencement Bay Nearshore/Tideflats Record of Decision (EPA, 1989).

Arsenic has leached or migrated into the groundwater in the area around the Pennwalt Ag-Chem fenceline and along Taylor Way in the north OFA/Pennwalt Area. The dissolved arsenic measured around the Ag-Chem fenceline area is probably due to selective leaching of this metal by high pH waters and/or the migration of groundwaters from beneath the Atochem Ag-Chem area. High pH conditions in groundwater in this area (9 to 12 pH units) likely originates from three above-ground storage tanks on the Ag-Chem property which held sodium hydroxide. The elevated arsenic in groundwater in the northeast site area around Taylor Way may be due to the migration of groundwaters from either the Atochem facility, the Reichhold property, or from sandblast waste found on the Blair Backup property. During at least part of the year the groundwater flow direction reverses, with flows originating from area beneath Taylor Way which move toward the Blair Backup property.

Generally, dissolved arsenic in the groundwater will move toward Taylor Way and likely discharge to the backfill around the underground sewer line. We estimate that the concentrations could be diluted by roughly

an order of magnitude by other groundwater moving through the backfill. Dilution alone will reduce the arsenic concentrations to below the Remedial Action Objective level of $40 \mu\text{g/L}$ proposed in the Draft Cleanup Action Plan for the 3009 Taylor Way woodwaste site (October 1991) which is adjacent to the Kaiser Ditch. The Kaiser Ditch is one of the likely receptors of groundwater migrating from the Blair Backup property. Dispersion and geochemical reactions are likely to further reduce arsenic concentrations to below levels of environmental concern before these groundwater discharge to the Hylebos Waterway.

If the groundwater does not discharge to the backfill it will flow beneath the Atochem facility and be captured by their groundwater pump and treat system. Atochem's cleanup standard for arsenic is $1,000 \mu\text{g/L}$. The groundwaters beneath the Blair Backup property are already well below the Atochem cleanup standard with average levels at $127 \mu\text{g/L}$ in the OFA/Pennwalt Area.

Recommended Actions for OFA/Pennwalt Area:

- ▶ **Remove Charcoal and Suspected Creosoted Timbers to Reduce the PAH Source.** Removal of charcoal alone will reduce the potential excess cancer risk from direct contact with OFA/Pennwalt area soils to 3×10^{-6} under the average industrial worker exposure assumptions. Under the average exposure conditions this area would then meet both the CERCLA (10^{-4}) and MTCA (10^{-5}) target risks for future industrial use. Under the RME exposure assumptions, the estimated risk is 3×10^{-5} which would slightly exceed the MTCA target threshold value.
- ▶ **Minimize the Potential for Long-Term Contact with the Soils in the Slag-Fill Area.** Arsenic and PAHs are the potentially carcinogenic chemicals identified in the OFA slag-fill area. Under the existing conditions (but without charcoal), the average lifetime exposure of workers to the PAHs and arsenic would result in an acceptable excess cancer risk of 9×10^{-6} . However, a potential risk of 5×10^{-5} was estimated for the maximum exposure scenario (RME case).
- ▶ **Control the Potential for Airborne Transport of Dusts from the Slag-Fill Portion of the OFA/Pennwalt Area.** Under average exposure conditions, the existing site risk is acceptable under both MTCA and CERCLA at 5×10^{-6} . However, under maximum

exposure conditions the site risk (2×10^{-5}) meets CERCLA but is slightly above the MTCA threshold of 10^{-5} .

- **Minimize the Transport of Slag Particulates in Surface Water Discharges.** Control of slag particulates in surface water runoff will the potential for arsenic and other metals detected in OFA Ditch sediment and surface waters to be discharged to the Hylebos Waterway.

We also recommend additional surface water sampling be performed to confirm the hypothesis that the principal mechanism for arsenic transport from the OFA Ditch is through sediment transport. The one dissolved surface sample obtained from the ditch exceeded the MTCA surface water cleanup level for arsenic as well as area reference water quality data. These results should be confirmed as we suspect the sample was biased because the ditch was blocked. The groundwater data in the slag-fill area do not indicate dissolved arsenic to be of concern.

8.2 North Site Area - Mercury and PAHs in Soil

Mercury was detected at relatively low concentrations (1 to 2 mg/kg) in the North Site Area. Only one sample slightly exceeded MTCA industrial soil cleanup levels and area reference concentrations. We do not consider this to be of concern considering that the exceedence was limited to one sample which only slightly exceeded the MTCA soil cleanup level of 1 mg/kg. In addition, the hazard index for direct contact and inhalation of mercury in the North Site Area is well below the Hazard Index of 1 for non-carcinogens.

PAHs were encountered at 3 locations in the central North Site Area but were not detected at levels above the MTCA Method A industrial soil cleanup levels of 20 mg/kg. The direct contact risk from PAHs in the North Site Area meets both the CERCLA and MTCA target risk levels under average and RME exposure assumptions.

There is no apparent source for the occurrence of the PAH compounds in this area. Access to this area from the Port's property is limited by wetland area, it does not appear to be the site of any previous land filling, and it lies adjacent to Reichhold's background area. There is a possibility that some of the PAHs are naturally occurring in this area

because of the great amount of naturally occurring peats and associated organics.

Both the mercury and the PAHs are relatively immobile under most conditions so are unlikely to migrate with surface or groundwaters. No off-site impacts are expected to occur from these chemicals.

Recommended Action for North Site Area Soils: No remediation is recommended.

8.3 North Site Area - Vinyl Chloride in Groundwater

Vinyl chloride was detected in several of the North Site Area wells at concentrations ranging from 5 to 85 $\mu\text{g/L}$, above the MTCA marine surface water cleanup level of 3.4 $\mu\text{g/L}$. Vinyl chloride is water soluble and highly volatile preferring to discharge to the air and migrate with the groundwater. It is a breakdown product of the commonly used solvents tetra- and tri-chloroethylene. Past releases from the former Reichhold septic system or from vehicle maintenance on the property are potential sources for this groundwater contamination.

The vinyl chloride is transported via groundwater toward the wetland during the dry season and toward Taylor Way during the wet season. The groundwater flow direction reversal will slow the transport of this chemical to either receptor. This also allows more time for natural degradation via volatilization reducing the potential for impact via groundwater discharges.

Groundwater that flows toward Taylor Way is likely to discharge to coarse-grained soil backfill around an underground sewer line that runs beneath Taylor Way, eventually discharging to the Lincoln Avenue Ditch and then the Hylebos Waterway. The dilution that is likely to occur in the sewer backfill as well as subsequent dilution, dispersion and volatilization should reduce levels to below the marine criteria before reaching the Hylebos Waterway.

Groundwater which flows toward the wetland eventually discharges to the Reichhold S Ditch. The vinyl chloride is likely to be degraded within the wetland area before reaching the ditch. No vinyl chloride was detected in the Reichhold S Ditch.

The principal potential for impact from the vinyl chloride is a human health risk due to inhalation of airborne vapor volatilized from groundwater. Under average exposure conditions, the risk (10^{-5}) is acceptable under both MTCA and CERCLA industrial exposure scenarios. Under the RME conditions, the risk (2×10^{-5}) is within the EPA target risk but slightly exceeds the MTCA threshold risk. If the rate of vinyl chloride degradation observed between January 1990 and December 1990 continues, the risk may already be or will soon be within acceptable levels.

Recommended Action for North Site Groundwater: No remediation is recommended. However, we recommend additional groundwater monitoring to confirm the natural degradation of vinyl chloride and reassessment of associated potential risks.

8.4 General/Fill Area - Metals in Groundwater and Surface Water

Nickel and zinc were detected in groundwater in the General/Fill Area at concentrations which exceeded the MTCA surface water cleanup levels, area reference groundwater concentrations, and regional surface water quality data. The highest concentrations were found in the central General/Fill Area. It is possible that sandblast waste dumped in the central portion of the General/Fill Area or some of the fill materials not explored in this area could act as a source for these metals. Fourteen soil samples from the General/Fill Area were analyzed for metals but all were within background levels.

Elevated levels of nickel and zinc in the Reichhold S Ditch surface water (above MTCA surface water cleanup levels) suggests that these metals may be migrating with the groundwater toward the ditch. However, the data also indicate that the metals are being attenuated as they move toward the ditch. The concentration of metals are well below the drinking water standards so pose no threat to human health. In addition, these metals have not been identified as a concern in the Lincoln Avenue Ditch or the Blair Waterway sediments. It is unlikely that these metals will cause any environmental impact because the Reichhold S Ditch waters are likely diluted as they enter the Lincoln Avenue Ditch and further attenuated by dispersion and dilution prior to reaching the Blair Waterway.

Recommended Action for Reichhold S Ditch Surface Water: Confirm the suspected attenuation of nickel and zinc levels prior to reaching the Blair Waterway and evaluate the potential for these metals to impact the marine environment. To do this we recommend additional sampling and analysis of the surface water and sediments in the Reichhold S Ditch to evaluate potential metals loading to the Lincoln Avenue Ditch and quantify the dilution that occurs upon reaching the ditch.

8.5 Recommended Institutional Controls

To address the human health risks identified on the property, institutional controls may be required for areas of the property, depending on the remedial actions undertaken. The need for institutional controls in the OFA slag-fill area will be evaluated in the remedial action alternatives analysis.

Institutional controls restricting the use of contaminated groundwater in the Shallow Aquifer should be placed on the Blair Backup property. Our evaluation of site groundwater indicates that insufficient quantities are available and the quality is unsuitable for water supply development. However, it is possible that either temporary or permanent withdrawals for dewatering purposes may be required during site development. Pretreatment of these waters may be required before discharge to sewer system or surface water depending on the water quality and specific area of dewatering.

Development in the North Site Area of the property should take into account the possible exposure of site workers to the emission of volatile organics (vinyl chloride) from the Shallow Aquifer. The potential excess cancer risk from inhalation of vapors in indoor air was estimated to be 10^{-5} for the average case and 2×10^{-5} for the RME case. We recommend that if structures are built on this portion of the property before further degradation of vinyl chloride has occurred, they should have integrally designed gas protection systems. Likely systems would include using the subslab drainage systems associated with any structure that might be built at the site as a passive venting system. This would act to divert vapors from the underside of building slabs. Depending on the computed potential levels of vapors, a more conservative method would be to place an impervious membrane (PVC, HDPE, etc.) directly below the slab to block any upward flow of vapors.

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Tables

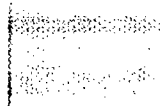
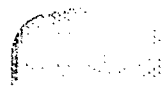
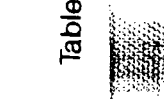


Table 1 - Summary of Analyses Performed on Soil Samples - Phase I

Sheet 1 of 2

Sample	Total Metals	EP Tox Metals	TCLP Metals	Volatile Organics	Semivolatile Organics	TCLP PAHs	GC-FID Screen	TPH (418.1)	Organo-phosphorous Pesticides	Chlorinated Herbicides	Pesticides/PCBs
<u>Ohio Ferro-Alloy/Pennwalt Area</u>											
TP108/S-2	X						X				
TP109/S-1	X						X		R	R	X
TP110/S-2	X						X		X	R	X
TP111/S-1	X	X					X		X	R	X
TP112/S-1	X			X	X		X				
TP124/S-1	X			X	X		X		X	R	
TP125/S-2	X	X					X				
TP126/S-1	X	X					X				
TP127/S-1	X						X				
TP128/S-1	X						X				
TP129/S-1	X						X				
TP130/S-2	X						X				
TP131/S-1	X			X			X				
TP132/S-1	X	X					X				
TP133/S-1	X						X				
TP134/S-1	X	X		X			X				
TP135/S-1	X						X				
HC-4S/S-1	X						X		X	R	X
HC-4S/S-2	X			X			X		X	R	X
HC-5S/S-1	X						X		X	R	X
HC-5S/S-2	X			X			X		X	R	X
HC-6S/S-1	X	X		X			X				
HC-10S/S-1	X						X				
HC-11S/S-1	X	X					X		X	R	
HC-12S/S-2	X						X				
HC-15S/S-1	X						X				
HC-15S/S-3	X						X				
HC-16S/S-1	X						X				
SS-2	X						X				
SS-3	X	X					X				
SS-7	X			X	X		X				
<u>Replicates</u>											
HC-10S/S-7	X						X				
SS-17	X						X				

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Table 1 - Summary of Analyses Performed on Soil Samples - Phase I

Sheet 2 of 2

Sample	Total Metals	EP Tox Metals	TCLP Metals	Volatile Organics	Semivolatile Organics	TCLP PAHs	GC-FID Screen	TPH (418.1)	Organo-phosphorous Pesticides	Chlorinated Herbicides	Pesticides/PCBs
<u>North Site Area</u>											
TP113/S-1	X			X	X						X
TP114/S-1	X			X	X						X
TP115/S-1	X			X	X						X
TP116/S-2	X			X	X						X
TP117/S-1	X						X				
TP118/S-1	X						X				
TP119/S-2	X						X				
HC-7S/S-2	X						X				
HC-8S/S-2	X			X	X		X				X
SS-4	X	X			X		X				
SS-5	X						X				
SS-6	X	X					X				
<u>General Fill Area</u>											
TP101/S-1	X			X	X						
TP102/S-2	X			X	X						
TP103/S-2	X			X	X						
TP104/S-1	X			X	X						
TP105/S-2	X						X				
TP106/S-1	X						X				
TP107/S-1	X			X	X		X				
HC-1S/S-2	X			X	X						
HC-2S/S-1	X						X				
HC-3S/S-2	X			X	X						
HC-13S/S-2	X						X				
HC-14S/S-1	X						X				
HC-17S/S-1					X		X				
HC-17S/S-3					X		X				
HC-18S/S-1					X		X				
SS-9	X						X				
SS-10	X						X				
<u>Replicates</u>											
HC-1S/S-5	X			X	X						

Table 2 - Summary of Analyses Performed on Soil Samples - Phase II

Sheet 1 of 2

Sample	Total Metals	EP Tox Metals	TCLP Metals	Volatile Organics	PAHs	TCLP PAHs	GC-FID Screen	TPH (418.1)
<u>Ohio Ferro-Alloy/Pennwalt Area</u>								
TP200/S-1					X	X	X	X
TP201/S-1					X	X	X	X
TP202/S-1							X	
TP203/S-1							X	
TP204/S-1							X	
TP205/S-1							X	X
TP205/S-2					X	X	X	
TP206/S-1					X		X	X
TP207/S-1					X	X	X	X
TP208/S-1							X	X
TP208/S-2	X							
TP209/S-1							X	
TP210/S-1					X	X	X	X
TP211/S-2							X	
HC-23/S-1	X						X	
HC-23/S-3	X						X	
HC-24/S-1	X						X	
HC-24/S-3	X						X	
HC-25/S-1	X						X	
HC-25/S-3	X						X	
HC-26/S-1	X						X	
HC-26/S-2	X						X	
SS-100							X	
SS-101							X	
SS-102					X		X	X
SS-103							X	
SS-104					X		X	X
SS-105	X							
CHARCOAL 9/90					X		X	
CHARCOAL 1/91					X		X	X
COAL 9/90					X		X	
WOOD CHIPS FRESH							X	
WOOD CHIPS AGED					X		X	X
COKE TP124 9/90							X	
SS-TCLP-1	X			X				
SS-TCLP-2	X			X				
SS-TCLP-3	X			X				
SS-TCLP-4	X			X				
SS-TCLP-5	X			X				

Table 2 - Summary of Analyses Performed on Soil Samples - Phase II

Sheet 2 of 2

Sample	Total Metals	EP Tox Metals	TCLP Metals	Volatile Organics	PAHs	TCLP PAHs	GC-FID Screen	TPH (418.1)
<u>North Site Area</u>								
HC-9S/S-1	X			X	X			
HC-9S/S-3	X			X	X			
HC-19S/S-2	X			X	X			
HC-21S/S-1	X			X	X			
HC-22S/S-1	X			X	X			
<u>Replicates</u>								
SS-200							X	
HC-24/S-4	X						X	

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Table 3 - Summary of Analyses Performed on Groundwater Samples

Sheet 1 of 4

Sample	Dissolved Metals	Volatile Organics	Semivolatile Organics	Formaldehyde	Field Parameters *	Organo- phosphorous Pesticides	Chlorinated Pesticides	PCBs	Chlorinated Herbicides
<u>Ohio Ferro-Alloy/Pennwalt Area</u>									
HC-10I	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-10S	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-6S	1,2,3	1,2,3	1,2,3	1(R),3	1,2,3		1	1	
HC-6I	1,2,3	1,2,3	1,2,3	1(R),3	1,2,3				
HC-5S	1,2,3	1,2,3	1,2,3	1(R),3	1,2,3	3	1,3	1,3	3
HC-4I	1,2,3	1,2,3	1,2,3	1(R),3	1,2,3		1	1	
HC-4S	1,2,3	1,2,3	1,2,3	1(R),3	1,2,3	3	1,3	1,3	3
HC-15S	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-15I	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-11S	1,3	1,2,3	1,2,3	1(R),3	1,2,3		1	1	
HC-12S	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-12I	1,2,3	1,2,3	1,2,3	1(R),3	1,2,3		1	1	
HC-16S	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-16I	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-24S	3	3	3	3	3				
HC-25S	3	3	3	3	3				
EPA-8I	1,2,3	1,2,3	1,2,3	1(R),3	1,2,3		1	1	
EPA-9S	1,2,3	1,2,3	1,2,3	1(R),3	1,2,3	3	1,3	1,3	3
EPA-10I	1,3	1,3	1,3	1(R),3	1,3		1	1	
EPA-6I	1,3	1,3	1,3	1(R),3	1,3		1	1	
EPA-7S	1,3	1,3	1,3	1(R),3	1,3		1	1	
<u>Replicates</u>									
HC-10SA	3	3	3	3					
HC-10I	A								
HC-100	2	2	2						
HC-12R	1	1	1	1(R)			1	1	
EPA-9R	1	1	1	1(R)			1	1	

Table 3 - Summary of Analyses Performed on Groundwater Samples

Sheet 2 of 4

Sample	Dissolved Metals	Volatile Organics	Semivolatile Organics	Formaldehyde	Field Parameters *	Organo- phosphorous Pesticides	Chlorinated Pesticides	PCBs	Chlorinated Herbicides
<u>General Fill Area</u>									
HC-17S	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-17I	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-18S	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-3I	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-3S	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-1S	1,3	1,3	1(R),3	1(R),3	1,3		1	1	
HC-13S	1,3	1,3	1(R),3(R)	1(R),3	1,3		1	1	
HC-2I	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-2S	1,3	1,3	1(R),3(R)	1(R),3	1,3		1	1	
HC-13I	1,3	1,3	1	1(R),3	1,3		1	1	
HC-14I	1,3	1,3	1,3	1(R),3	1,3		1	1	
HC-14S	1,3	1,3	1,3	1(R),3	1,3		1	1	
<u>North Site Area</u>									
HC-7S	1,2,3	1,2,3	1,2,3	1(R),3	1,2,3		1	1	
HC-8S	1,2,3	1,2,3	1,2,3	1(R),3	1,2,3		1	1	
HC-9S	2,3	2,3	2,3	3	2,3				
HC-21S	3	2,3	2,3	3	2,3				
<u>Replicates</u>									
HC-3R	1	1	1	1(R)			1	1	
HC-8SA	3	3	3	3					

Notes:

A Analyzed for Arsenic(+3) and Arsenic(+5) only.

* pH, Temperature in °C, Specific Conductivity, Dissolved Oxygen.

1 Round one - wet season - January 1990

2 Round two - dry season - October 1990

3 Round three - wet season - December 1990

Table 3 - Summary of Analyses Performed on Groundwater Samples

Sheet 3 of 4

Sample	Total Dissolved Solids	Total Suspended Solids	Fluoride	Hardness as CaCO ₃	Calcium	Chloride	Hydrogen Sulfide as S	Magnesium	Sodium	Sulfate as SO ₄	Total Alkalinity as CaCO ₃
<u>Ohio Ferro-Alloy/Pennwalt Area</u>											
HC-10I	1,3	3	3								
HC-10S	1,3	3	3	3							
HC-6S	1,2,3	2,3	3	3							
HC-6I	1,2,3	2,3	3								
HC-5S	1,2,3	2,3	3	3	3	3	3	3	3	3	3
HC-4I	1,2,3	2,3	3								
HC-4S	1,2,3	2,3	3	3	3	3	3	3	3	3	3
HC-15S	1,3	3	3	3							
HC-15I	1,3	3	3								
HC-11S	1,2,3	2,3	3	3	3	3		3	3	3	3
HC-12S	1,3	3	3	3							
HC-12I	1,2,3	2,3	3								
HC-16S	1,3	3	3	3							
HC-16I	1,3	3	3								
HC-24S	3	3	3	3							
HC-25S	3	3	3	3							
EPA-8I	1,2,3	2,3	3								
EPA-9S	1,2,3	2,3	3	3	3	3	3	3	3	3	3
EPA-10I	1,3	3	3	3							
EPA-6I	1,3	3	3								
EPA-7S	1,3	3	3	3							
<u>Replicates</u>											
HC-10SA	3	3	3	3							
HC-10I											
HC-100	2	2									
HC-12R	1										
EPA-9R	1										

Table 3 - Summary of Analyses Performed on Groundwater Samples

Sheet 4 of 4

Sample	Total Dissolved Solids	Total Suspended Solids	Fluoride	Hardness as CaCO ₃	Calcium	Chloride	Hydrogen Sulfide as S	Magnesium	Sodium	Sulfate as SO ₄	Total Alkalinity as CaCO ₃
<u>General Fill Area</u>											
HC-17S	1,3	3	3	3							
HC-17I	1,3	3	3								
HC-18S	1,3	3	3	3							
HC-3I	1,3	3	3								
HC-3S	1,3	3	3	3							
HC-1S	1,3	3	3	3							
HC-13S	1,3	3	3	3							
HC-2I	1,3	3	3								
HC-2S	1,3	3	3	3							
HC-13I	1										
HC-14I	1,3	3	3								
HC-14S	1,3	3	3	3							
<u>North Site Area</u>											
HC-7S	1,2,3	2,3	3	3							
HC-8S	1,2,3	2,3	3	3							
HC-9S	2,3	2,3	3	3							
HC-21S	2,3	2,3	3	3							
<u>Replicates</u>											
HC-3R	1										
HC-8SA	3	3	3	3							

Table 4 - Average Linear Velocity and Volumetric Flow Rate in the Shallow Aquifer

Area and Receptor of Groundwater Flow	Hydraulic Gradient	Saturated Thickness in Feet	Flow Tube Width in Feet	Average Linear Velocity in ft/day	Volumetric Flow in gpm
OFA/Pennwalt Area					
Taylor Way					
Feb. 1990	0.005	7.5	1600	0.03	0.5
Sept. 1990	0.004	5.5	1100	0.02	0.2
Jan. 1991	0.003	8.0	1500	0.02	0.3
Reichhold S Ditch					
Feb. 1990	0.004	7.5	600	0.02	0.2
Sept. 1990	0.003	5.5	750	0.02	0.1
Jan. 1991	0.008	8.0	550	0.05	0.3
North Site Area					
Taylor Way					
Feb. 1990	0.005	6.4 to 7.3	550	0.03	0.2
Jan. 1991	.004 to 0.006	5.3	550	0.02 to 0.03	0.1 to 0.2
Reichhold S Ditch					
Feb. 1990	0.005	5.3	680	0.03	0.2
Sept. 1990	0.002	5.0	680	0.01	0.1
Jan. 1991	0.007	3.4	960	0.04	0.2
General/Fill Area					
Reichhold S Ditch					
Feb. 1990	0.008 to 0.01	3.6 to 8.0	600 to 650	0.05 to 0.06	0.2 to 0.5
Sept. 1990	.004 to 0.005	6.0	600	0.02 to 0.03	0.1 to 0.2
Jan. 1991	.011 to 0.015	1.0 to 8.8	500 to 650	0.06 to 0.09	0.05 to 0.8

Notes:

For average linear velocity and volumetric flow estimations, the geometric mean hydraulic conductivity (0.0007) was used.

GPM = gallons per minute.

A porosity of 0.3 was used in average linear velocity estimates.

Table 5 - Average Linear Velocity in the Intermediate Aquifer

Flowpath	Hydraulic Gradient	Hydraulic Conductivity in cm/sec	Porosity	Average Linear Velocity in in ft/day
Reichhold S Ditch Area to Center of Site				
Feb. 1990	to 0.003	0.001	0.3	0.02 to 0.03
Sept. 1990	to 0.003	0.001	0.3	0.01 to 0.03
Jan. 1991	to 0.004	0.001	0.3	0.01 to 0.04
Kaiser Area to Center of Site				
Feb. 1990	0.003	0.001	0.3	0.03
Sept. 1990	to 0.003	0.001	0.3	0.01 to 0.03
Jan. 1991	0.004	0.001	0.3	0.04

Note:

The geometric mean of the hydraulic conductivity was used to estimate velocities.

Table 6 - Data Qualifiers and Cross Reference Notes for Tables 7 through 23

Averages and upper 95th confidence limit of the mean for cPAHs were adjusted using relative potency estimates (Thorslund, personal communication, 1990), currently under Science Advisory Board review.

All soil sample and ditch sediment data are reported on dry weight basis.

MTCA tables for Industrial Soil and Surface Water/Groundwater cleanup levels (Tables 6 and 7) were generated in April 1991. MTCA tables for residential use (Appendix C) were generated in July 1991.

Surface water cleanup levels do not address risk due to multiple exposure pathways or multiple contaminants.

- A Ecology, February 1991 MTCA Method A residential soil cleanup levels. (Chapter 173-340-740, Table 2).
- B Indicates analyte was detected in laboratory method blank.
- D Value reported derives from analysis of a diluted sample or sample extract.
- J Indicates an estimated value.
- ND Not detected at various detection limits.
- T Flagged values represent sum of two coeluting compounds.
- U Indicates compound was analyzed for but not detected at the given detection limit.
 - (a) Calculated using one-half of the detection limit for non-detected compounds.
 - (b) Practical quantitation limit using EPA method 206.3.
 - (c) Practical quantitation limit using EPA method 210.2.
 - (d) Marine criteria for hexavalent chromium.
 - (e) Practical quantitation limit using EPA method 245.2.
 - (f) Cleanup standard based on 10^{-6} cancer risk for benzo(a)pyrene.
 - (g) Ecology, February 1991 MTCA Cleanup Levels (Chapter 173-340 WAC). Oral references doses and oral slope factors obtained from Health Effects Assessment Summary Tables (HEAST) EPA, January 1991.
 - (h) For hexavalent chromium only; cleanup levels for trivalent chromium and total chromium are greater than 65,000 ppm.
 - (i) Resource Conservation and Recovery Act criteria (Chapter 173-303 WAC and 40 CFR Part 26).
 - (j) Toxicity Characteristics Revisions (40 CFR Part 261).
 - (k) July 1990 metals data for wells MW-28I and MW-29I were not included due to quality control problems.
 - (l) After silica gel cleanup.
 - (m) Samples were collected in Bellevue, Washington, as part of Metro's Toxicants in Urban Runoff Study (December 1982).

Table 6 - Continued

- (n) Samples were collected from the Puyallup River during January and May 1984 as part of a Puyallup River Valley water quality investigation conducted by the U.S. Geological Survey (Ebbert et al., 1986).
- (o) Data obtained from Reichhold Chemical report "Sediment and Surface Water Report: Offsite Drainageways" (CH2M Hill, 1989c).
- (p) Upper 95th Background Limit was calculated using Lands (Gilbert, 1987) equation for determining confidence limits of lognormal distributions.
- (q) Pevear, D., Geology Department, Western Washington University, unpublished data cited in Dexter et al., 1981.
- (r) Shacklette and Boerngen, 1984.
- (s) Harper-Owes, 1985.
- (t) EPA criteria provided for trivalent chromium only.
- (u) Ecology, February 1991 MTCA Cleanup Levels (Chapter 173-340-730(3)(a)(III)(A). Values calculated using oral reference doses provided in HEAST, EPA 1991, and Bioconcentration Factors provided in EPA Criteria Chart, January 1991.
- (v) Ecology, February 1991 MTCA Cleanup Levels (Chapter 173-340-730(3)(a)(III)(B). Values calculated using oral reference doses provided in HEAST, EPA 1991, and Bioconcentration Factors provided in EPA Criteria Chart, January 1991.
- (w) Lowest Observed Effect Level (LOEL) Goldbook, EPA, 1986.
- (x) Based on the oral reference dose for food, HEAST 1991.
- (y) Based on the more toxic form (hexavalent) chromium.
- (z) The estuarine/coast organisms bioconcentration factors provided in the EPA Criteria Chart, January 1991.
- (aa) Based on oral reference dose for water.
- (ab) Ecology, April 1991, Sediment Management Standards, Table 1 Marine Sediment Quality Standards - Chemical Criteria (for designation of sediments).
- (ac) Clean Water Act, Marine Chronic Criteria, obtained from EPA Region IV Criteria Chart, January 1991.
- (ad) Clean Water Act, Criteria for Protection of Human Health from Consumption of Aquatic Organisms Only, EPA Region IV Criteria Chart, January 1991.
- (ae) Clean Water Act, Marine Acute Criteria, obtained from EPA Region IV Criteria Chart, January 1991.
- (af) For non-carcinogenic PAHs based on oral reference dose for naphthalene.
 - >> Greater than 75,000 $\mu\text{g/L}$ for groundwater; greater than 300,000 ppm for soil.
 - >>> Greater than 200,000 $\mu\text{g/L}$ for groundwater.

Table 7 - MTCA Soil and Sediment Cleanup Levels

Sheet 1 of 3

	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Marine Sediment Quality Levels (ab)
Total Metals			
in mg/kg (ppm)			
Arsenic	200	190 (aa)	57
Cadmium	10	1,800	5.1
Chromium	500	18,000 (h)	260
Copper	—	>>	390
Lead	1,000	—	450
Manganese	—	>>	—
Mercury	1	1,000	0.41
Nickel	—	70,000	—
Selenium	—	—	—
Silver	—	10,500	6.1
Zinc	—	>>	410
EP Tox Metals			
in mg/L (ppm)	Dangerous Waste Limits (i)		
Arsenic	5.0	—	—
Barium	100.0	—	—
Cadmium	1.0	—	—
Chromium	5.0	—	—
Copper	—	—	—
Lead	5.0	—	—
Mercury	0.2	—	—
Nickel	—	—	—
Zinc	—	—	—
TCLP Metals			
in mg/L (ppm)	Toxicity Characteristic Maximum Concentrations (j)		
Arsenic	5	—	—
Barium	100	—	—
Cadmium	1.0	—	—
Chromium	5.0	—	—
Copper	—	—	—
Lead	5.0	—	—
Mercury	0.2	—	—
Nickel	—	—	—
Selenium	1.0	—	—
Silver	5.0	—	—
Zinc	—	—	—

Table 7 - MTCA Soil and Sediment Cleanup Levels

	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Marine Sediment Quality Levels (ab)
Volatile Organic Compounds			
in mg/kg (ppm)			
Vinyl chloride	—	70	—
Methylene Chloride	0.5	18,000	—
Acetone	—	>>	—
Carbon disulfide	—	—	—
trans-1,2-Dichloroethene	—	70,000	—
cis-1,2-Dichloroethene	—	35,000	—
Total 1,2-Dichloroethene	—	—	—
2-Butanone (MEK)	—	>>	—
1,2-Dichloroethane	—	1,400	—
Trichloroethene	0.5	12,000	—
Benzene	0.5	4,500	—
Toluene	40	>>	—
Ethylbenzene	20	>>	—
Total Xylene	20	>>	—
Semivolatile Organic Compounds			
in mg/kg (ppm)			
Dibenzofuran	—	>>	15
4-Methylphenol	—	>>	670
Bis(2-ethylhexyl)phthalate	—	9,400	47
Di-n-octyl phthalate	—	70,000	58
Carcinogenic PAHs			
in mg/kg (ppm)	20	11	960
Non-carcinogenic PAHs			
in mg/kg (ppm)			
Acenaphthene	—	210,000	16
Acenaphthylene	—	>>	66
Anthracene	—	>>	220
Benzo(g,h,i)perylene	—	>>	31
Fluoranthene	—	140,000	160
Fluorene	—	140,000	23
2-Methylnaphthalene	—	>>	38
Naphthalene	—	14,000	99
Phenanthrene	—	>>	100
Pyrene	—	105,000	1000
Total Non-carcinogenic PAHs	—	14,000 (af)	—

Table 7 - MTCA Soil and Sediment Cleanup Levels

Sheet 3 of 3

	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Marine Sediment Quality Levels (ab)
Pesticides/PCBs			
in mg/kg (ppm)			
4,4'-DDE	—	390	—
4,4'-DDD	—	550	—
4,4'-DDT	5.0	390	—
TCLP Polynuclear Aromatic			
Hydrocarbons in mg/L (ppm)			
Napthalene	—	—	—
Acenaphthylene	—	—	—
Acenaphthene	—	—	—
Fluorene	—	—	—
Phenanthrene	—	—	—
Anthracene	—	—	—
Fluoranthene	—	—	—
Pyrene	—	—	—
Benzo(a)anthracene	—	—	—
Chrysene	—	—	—
Benzo(b)fluoranthene	—	—	—
Benzo(k)fluoranthene	—	—	—
Benzo(a)pyrene	—	—	—
Dibenzo(a,h)anthracene	—	—	—
Benzo(g,h,i)perylene	—	—	—
Indeno(1,2,3-cd)pyrene	—	—	—
Miscellaneous Parameters			
in mg/kg (ppm)			
GC-FID Screen	—	—	—
GC-FID Screen 8015 Modified	200	—	—
GC-FID Screen 8015 Modified (1)	200	—	—
TPH (418.1)	200	—	—
Organophosphorous Pesticides	—	—	—
in mg/kg (ppm)			
Chlorinated Herbicides	—	—	—
in mg/kg (ppm)			
Chlorinated Pesticides	—	—	—
in mg/kg (ppm)			
Total Organic Carbon in %	—	—	—

Table 8 - MTCA Groundwater Cleanup Levels

Sheet 1 of 3

MTCA Method B
Surface Water
Cleanup Levels (g)

Dissolved Metals

in $\mu\text{g/L}$ (ppb)

Antimony	1,040 (u)
Arsenic	2.0 (b)
Arsenic (+3)	---
Arsenic (+5)	---
Barium	>50,000 (ac)
Beryllium	1.0 (c)
Cadmium	9.3 (ac)
Chromium	50
Chromium (+6)	---
Copper	2.9 (ac)
Iron	---
Lead	5.6 (ac)
Manganese	100 (ad)
Mercury	0.2 (e)
Molybdenum	---
Nickel	8.3 (ac)
Selenium	71 (ac)
Silver	2.3 (ae)
Thallium	1.5 (u)
Zinc	86 (ac)

Volatile Organic Compounds

in $\mu\text{g/L}$ (ppb)

Vinyl chloride	2.9 (v)
Methylene chloride	960 (u)
Acetone	---
trans-1,2-Dichloroethene	4,850 (u)
cis-1,2-Dichloroethene	---
Total 1,2-Dichloroethene	---
2-Butanone (MEK)	---
Trichloroethene	56 (v)
Benzene	43 (v)
Tetrachloroethene	4.1 (v)
Toluene	5,000 (ac)
Ethylbenzene	430 (ae)
Total Xylene	>> (u)

Table 8 - MTCA Groundwater Cleanup Levels

Sheet 2 of 3

MTCA Method B Surface Water Cleanup Levels (g)	
Miscellaneous Parameters	
in $\mu\text{g/L}$ (ppb)	
Formaldehyde	---
Miscellaneous Parameters	
in mg/L (ppm)	
Total Dissolved Solids	---
Total Suspended Solids	---
Fluoride	---
Hardness as CaCO_3	---
Calcium	---
Chloride	---
Hydrogen Sulfide as S	---
Magnesium	---
Sodium	---
Sulfate as SO_4	---
Total Alkalinity as CaCO_3	---
Semivolatile Organic Compounds	
in $\mu\text{g/L}$ (ppb)	
Phenol	5,800 (ae)
4-Methylphenol	---
Benzoic acid	---
Dibenzofuran	---
Bis(2-ethylhexyl)phthalate	3.6 (v)
Di-n-octyl phthalate	---
Non-carcinogenic PAHs	
in $\mu\text{g/L}$ (ppb)	
Acenaphthene	643 (u)
Acenaphthylene	---
Anthracene	107,700 (ad)
Benzo(g,h,i)perylene	---
Fluoranthene	90 (u)
Fluorene	14,360 (ad)
2-Methylnaphthalene	---
Naphthalene	1,000 (u)
Phenanthrene	---
Pyrene	10,770 (ad)
Total Non-carcinogenic PAHs	---

Table 8 - MTCA Groundwater Cleanup Levels

Sheet 3 of 3

MTCA Method B Surface Water Cleanup Levels (g)	
Carcinogenic PAHs in $\mu\text{g/L}$ (ppb)	0.02 (f,v)
Field Parameters	
pH	---
Temperature in $^{\circ}\text{C}$	---
Specific Conductivity in μMhos	---
Dissolved Oxygen in ppm	---
Organophosphorous Pesticides in $\mu\text{g/L}$ (ppb)	---
Chlorinated Pesticides in $\mu\text{g/L}$ (ppb)	---
PCBs in $\mu\text{g/L}$ (ppb)	---
Chlorinated Herbicides in $\mu\text{g/L}$ (ppb)	
2,4-DB	---
Dinoseb	---

Note: Data qualifiers and cross references are presented in Table 6.

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Table 9 - Statistical Summary and MTCA Exceedences in General/Fill Area Soil Samples

Sheet 1 of 2

<u>Excluding Waste Material Samples</u>	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	Number of Samples Exceeding Levels/ Number Analyzed	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Number of Samples Exceeding Levels/ Number Analyzed
Total Metals									
in mg/kg (ppm)									
Arsenic	12 / 13	12	TP107/S-1	3.234	4.576	200	0 / 13	190 (aa)	0 / 13
Cadmium	6 / 13	1.1	HC-2S/S-1	0.533	0.697	10	0 / 13	1,800	0 / 13
Chromium	13 / 13	27 B	TP107/S-1	17.92	20.53	500	0 / 13	18,000 (h)	0 / 13
Copper	13 / 13	60	TP107/S-1	19.80	26.30	---	---	>>	0 / 13
Lead	4 / 13	43	TP107/S-1	9.884	15.02	1,000	0 / 13	---	---
Mercury	0 / 13	0.1 U	----	---	---	1	0 / 13	1,000	0 / 13
Nickel	12 / 13	200	SS-10 Fill	25.77	50.96	---	---	70,000	0 / 13
Zinc	13 / 13	65 B	TP107/S-1	29.84	36.78	---	---	>>	0 / 13
Volatile Organic Compounds									
in mg/kg (ppm)									
Vinyl chloride	0 / 7	0.002 U	----	---	---	---	---	70	0 / 7
Acetone	0 / 7	0.14 U	----	---	---	---	---	>>	0 / 7
Carbon disulfide	1 / 7	0.004	TP103/S-2	0.001	---	---	---	---	---
trans-1,2-Dichloroethene	0 / 7	0.002 U	----	---	---	---	---	70,000	0 / 7
cis-1,2-Dichloroethene	0 / 7	0.002 U	----	---	---	---	---	35,000	0 / 7
Total 1,2-Dichloroethene	0 / 7	0.002 U	----	---	---	---	---	---	---
2-Butanone (MEK)	2 / 7	0.016	HC-1S/S-2	0.005	0.009	---	---	>>	0 / 7
Trichloroethene	0 / 7	0.002 U	----	---	---	0.5	0 / 7	12,000	0 / 7
Benzene	0 / 7	0.002 U	----	---	---	0.5	0 / 7	4,500	0 / 7
Toluene	0 / 7	0.002 U	----	---	---	40	0 / 7	>>	0 / 7
Ethylbenzene	0 / 7	0.002 U	----	---	---	20	0 / 7	>>	0 / 7
Total Xylene	0 / 7	0.002 U	----	---	---	20	0 / 7	>>	0 / 7
Miscellaneous Parameters									
in mg/kg (ppm)									
GC-FID Screen	5 / 10	590	TP107/S-1	85.77	186.0	---	---	---	---
Semivolatile Organic Compounds									
in mg/kg (ppm)									
Dibenzofuran	0 / 7	0.16 U	----	---	---	---	---	>>	0 / 7
Bis(2-ethylhexyl)phthalate	0 / 7	0.59 U	----	---	---	---	---	9,400	0 / 7
Di-n-octyl phthalate	1 / 7	0.41 B	HC-3S/S-2	0.085	---	---	---	70,000	0 / 7

Table 9 - Statistical Summary and MTCA Exceedences in General/Fill Area Soil Samples

Sheet 2 of 2

<u>Excluding Waste Material Samples</u>	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	Number of Samples Exceeding Levels/ Number Analyzed	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Number of Samples Exceeding Levels/ Number Analyzed
Carcinogenic PAHs in mg/kg (ppm)	1 / 10	0.42	TP103/S-2	0.162		20	0 / 10	11	0 / 10
Non-carcinogenic PAHs in mg/kg (ppm)									
Acenaphthene						---	---	210,000	0 / 10
Acenaphthylene						---	---	>>	0 / 10
Anthracene						---	---	>>	0 / 10
Benzo(g,h,i)perylene						---	---	>>	0 / 10
Fluoranthene						---	---	140,000	0 / 10
Fluorene						---	---	140,000	0 / 10
2-Methylnaphthalene						---	---	>>	0 / 10
Naphthalene						---	---	14,000	0 / 10
Phenanthrene						---	---	>>	0 / 10
Pyrene						---	---	105,000	0 / 10
Total Non-carcinogenic PAHs	2 / 10	5.59	TP107/S-1	0.852	1.768	---	---	14,000 (af)	0 / 10

Note: Data qualifiers and cross references are presented in Table 6.

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Table 10 - Statistical Summary and MTCA Exceedences in North Site Area Soil Samples

Sheet 1 of 2

<u>Excluding Waste Material Samples</u>	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	Number of Samples Exceeding Levels/ Number Analyzed	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Number of Samples Exceeding Levels/ Number Analyzed
Total Metals									
in mg/kg (ppm)									
Arsenic	14 / 14	27 J	TP116/S-2	12.52	16.46	200	0 / 14	190 (aa)	0 / 14
Cadmium	5 / 14	2.4	TP118/S-1	0.665	0.988	10	0 / 14	1,800	0 / 14
Chromium	14 / 14	34 B	TP119/S-2	20.71	23.77	500	0 / 14	18,000 (h)	0 / 14
Copper	14 / 14	170	TP116/S-2	40.92	59.23	---	---	>>	0 / 14
Lead	9 / 14	68	TP118/S-1	18.64	27.00	1,000	0 / 14	---	---
Mercury	4 / 14	2	TP116/S-2	0.335	0.605	1	2 / 14	1,000	0 / 14
Nickel	14 / 14	160	TP116/S-2	27.51	45.50	---	---	70,000	0 / 14
Zinc	14 / 14	120 B	TP118/S-1	50.35	62.55	---	---	>>	0 / 14
Volatile Organic Compounds									
in mg/kg (ppm)									
Vinyl chloride	2 / 10	0.008	HC-21/S-1	0.002	0.003	---	---	70	0 / 10
Methylene Chloride	2 / 10	0.002	HC-9S/S-1, 19S/S-2	0.001	0.001	0.5	0 / 10	18,000	0 / 10
Acetone	5 / 10	0.12	HC-9S/S-1	0.081	0.105	---	---	>>	0 / 10
Carbon disulfide	0 / 10	0.003 U	----	---	---	---	---	---	---
trans-1,2-Dichloroethene	1 / 10	0.002	TP116/S-2	0.001	---	---	---	70,000	0 / 10
cis-1,2-Dichloroethene	2 / 10	0.008	TP116/S-2	0.001	0.003	---	---	35,000	0 / 10
Total 1,2-Dichloroethene	2 / 10	0.01	TP116/S-2	0.002	0.003	---	---	---	---
2-Butanone (MEK)	3 / 10	0.036	TP114/S-1	0.008	0.015	---	---	>>	0 / 10
Trichloroethene	0 / 10	0.003 U	----	---	---	0.5	0 / 10	12,000	0 / 10
Benzene	0 / 10	0.003 U	----	---	---	0.5	0 / 10	4,500	0 / 10
Toluene	0 / 10	0.003 U	----	---	---	40	0 / 10	>>	0 / 10
Ethylbenzene	0 / 10	0.003 U	----	---	---	20	0 / 10	>>	0 / 10
Total Xylene	0 / 10	0.003 U	----	---	---	20	0 / 10	>>	0 / 10
Semivolatile Organic Compounds									
in mg/kg (ppm)									
Dibenzofuran	1 / 10	0.1	HC-21S/S-1	0.041	---	---	---	>>	0 / 10
Bis(2-ethylhexyl)phthalate	3 / 10	0.19	HC-9S/S-1	0.127	0.183	---	---	9,400	0 / 10
Di-n-octyl phthalate	1 / 10	0.55	HC-8S/S-2	0.081	---	---	---	70,000	0 / 10
Carcinogenic PAHs									
in mg/kg (ppm)									
	8 / 10	18.35	TP-115/S-1	0.925	1.403	20	0 / 10	11	3 / 10

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Table 10 - Statistical Summary and MTCA Exceedences in North Site Area Soil Samples

Sheet 2 of 2

<u>Excluding Waste Material Samples</u>	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (s)	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	Number of Samples Exceeding Levels/ Number Analyzed	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Number of Samples Exceeding Levels/ Number Analyzed
Non-carcinogenic PAHs									
in mg/kg (ppm)									
Acenaphthene						---	---	210,000	0 / 10
Acenaphthylene						---	---	>>	0 / 10
Anthracene						---	---	>>	0 / 10
Benzo(g,h,i)perylene						---	---	>>	0 / 10
Fluoranthene						---	---	140,000	0 / 10
Fluorene						---	---	140,000	0 / 10
2-Methylnaphthalene						---	---	>>	0 / 10
Naphthalene						---	---	14,000	0 / 10
Phenanthrene						---	---	>>	0 / 10
Pyrene						---	---	105,000	0 / 10
Total Non-carcinogenic PAHs	8 / 10	28.31	TP-115/S-1	9.143	14.38	---	---	14,000 (af)	0 / 10
Miscellaneous Parameters									
in mg/kg (ppm)									
GC-FID Screen	2 / 5	26	HC-8S/S-2	11.4	19.45	---	---	---	---
Pesticides/PCBs									
in mg/kg (ppm)									
	0 / 5	ND	----			---	---	---	---

Note: Data qualifiers and cross references are presented in Table 6.

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Table 11 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy/Pennwalt Area Soil Samples

Sheet 1 of 3

Excluding Waste Material Samples	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	Number of Samples Exceeding Levels/ Number Analyzed	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Number of Samples Exceeding Levels/ Number Analyzed
Total Metals in mg/kg (ppm)									
Arsenic	45 / 45	240 J	SS-TCLP-1	48.77	64.34	200	2 / 45	190 (aa)	2 / 45
Cadmium	35 / 45	11	TP132/S-1	1.453	1.868	10	1 / 45	1,800	0 / 45
Chromium	44 / 45	3,000	HC-11S/S-1	191.5	317.7	500	4 / 45	18,000 (h)	0 / 45
Copper	45 / 45	1,500	TP125/S-2	163.0	227.3	---	---	>>	0 / 45
Lead	29 / 45	1,100	TP125/S-2	105.5	155.8	1,000	1 / 45	---	---
Manganese	8 / 8	110	HC-25 S-3 & HC-26	80.93	94.70	---	---	>>	0 / 45
Mercury	21 / 45	2	TP130/S-2	0.195	0.289	1	1 / 45	1,000	0 / 45
Nickel	44 / 45	290	TP110/S-2	34.53	47.62	---	---	70,000	0 / 45
Selenium	0 / 5	5 U	---	---	---	---	---	---	---
Silver	0 / 5	1 U	---	---	---	---	---	10,500	0 / 45
Zinc	45 / 45	550 B	TP132/S-1	137.8	171.8	---	---	>>	0 / 45
EP Tox Metals in mg/L (ppm)									
Arsenic	0 / 8	0.2 U	---	---	---	Dangerous Waste Limits (i) 5.0	0 / 8	---	---
Barium	7 / 8	0.3	TP125/S-2	0.181	0.228	100.0	0 / 8	---	---
Cadmium	0 / 8	0.01 U	---	---	---	1.0	0 / 8	---	---
Chromium	0 / 8	0.1 U	---	---	---	5.0	0 / 8	---	---
Copper	2 / 8	1.7 J	TP126/S-1	0.3	0.662	---	---	---	---
Lead	1 / 8	1.8 J	TP126/S-1	0.268	---	5.0	0 / 8	---	---
Mercury	0 / 8	0.005 U	---	---	---	0.2	0 / 8	---	---
Nickel	1 / 8	0.2	HC-11S/S-1	0.068	---	---	---	---	---
Zinc	6 / 8	0.5 J	TP132/S-1	0.25	0.359	---	---	---	---
TCLP Metals in mg/L (ppm)									
Arsenic	1 / 5	0.42	SS-TCLP-1	0.164	---	Toxicity Characteristic Maximum Concentrations (j) 5	0 / 5	---	---
Barium	5 / 5	0.71	SS-TCLP-1	0.538	0.635	100	0 / 5	---	---
Cadmium	0 / 5	0.01 U	---	---	---	1.0	0 / 5	---	---
Chromium	0 / 5	0.1 U	---	---	---	5.0	0 / 5	---	---
Copper	0 / 5	0.1 U	---	---	---	---	---	---	---
Lead	0 / 5	0.1 U	---	---	---	5.0	0 / 5	---	---
Mercury	0 / 5	0.005 U	---	---	---	0.2	0 / 5	---	---
Nickel	0 / 5	0.1 U	---	---	---	---	---	---	---
Selenium	0 / 5	0.2 U	---	---	---	1.0	0 / 5	---	---
Silver	0 / 5	0.1 U	---	---	---	5.0	0 / 5	---	---
Zinc	5 / 5	0.55	SS-TCLP-5	0.492	0.531	---	---	---	---

Table 11 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy/Pennwalt Area Soil Samples

Sheet 2 of 3

Excluding Waste Material Samples	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	Number of Samples Exceeding Levels/ Number Analyzed	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Number of Samples Exceeding Levels/ Number Analyzed
Volatile Organic Compounds in mg/kg (ppm)									
Vinyl chloride	0 / 7	0.002 U	----			---	---	70	0 / 7
Acetone	0 / 7	0.3 U	----			---	---	>>	0 / 7
Carbon disulfide	0 / 7	0.002 U	----			---	---	---	---
trans-1,2-Dichloroethene	0 / 7	0.002 U	----			---	---	70,000	0 / 7
cis-1,2-Dichloroethene	0 / 7	0.002 U	----			---	---	35,000	0 / 7
Total 1,2-Dichloroethene	0 / 7	0.002 U	----			---	---	---	---
2-Butanone (MEK)	1 / 7	0.054	HC-5S/S-2	0.010		---	---	>>	0 / 7
1,2-Dichloroethane	0 / 7	0.002 U	----			---	---	1,400	0 / 7
Trichloroethene	0 / 7	0.002 U	----			0.5	0 / 7	12,000	0 / 7
Benzene	0 / 7	0.002 U	----			0.5	0 / 7	4,500	0 / 7
Toluene	1 / 7	0.004	TP131/S-1	0.001		40	0 / 7	>>	0 / 7
Ethylbenzene	0 / 7	0.002 U	----			20	0 / 7	>>	0 / 7
Total Xylene	1 / 7	0.005	HC-4S/S-2	0.001		20	0 / 7	>>	0 / 7
Semivolatile Organic Compounds in mg/kg (ppm)									
Dibenzofuran	2 / 3	120 J	TP-207 Rep.	40.53	135.2	---	---	>>	0 / 3
Bis(2-ethylhexyl)phthalate	0 / 3	240 U	----			---	---	9,400	0 / 3
Di-n-octyl phthalate	0 / 3	240 U	----			---	---	70,000	0 / 3
Carcinogenic PAHs in mg/kg (ppm)									
	10 / 10	8,930	TP-207 Rep.	249.4	658.5	20	5 / 10	11	7 / 10
Non-carcinogenic PAHs in mg/kg (ppm)									
Acenaphthene						---	---	210,000	0 / 10
Acenaphthylene						---	---	>>	0 / 10
Anthracene						---	---	>>	0 / 10
Benzo(g,h,i)perylene						---	---	>>	0 / 10
Fluoranthene						---	---	140,000	0 / 10
Fluorene						---	---	140,000	0 / 10
2-Methylnaphthalene						---	---	>>	0 / 10
Naphthalene						---	---	14,000	0 / 10
Phenanthrene						---	---	>>	0 / 10
Pyrene						---	---	105,000	0 / 10
Total Non-carcinogenic PAHs	10 / 10	15,440	TP-207 Rep.	1614.	4287.	---	---	14,000 (af)	1 / 10

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Table 11 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy/Pennwalt Area Soil Samples

Sheet 3 of 3

<u>Excluding Waste Material Samples</u>	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	Number of Samples Exceeding Levels/ Number Analyzed	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Number of Samples Exceeding Levels/ Number Analyzed
Pesticides/PCBs									
in mg/kg (ppm)									
4,4'-DDE	1 / 7	0.029	TP111/S-1	0.013		---	---	390	0 / 7
4,4'-DDD	1 / 7	0.17	TP111/S-1	0.033		---	---	550	0 / 7
4,4'-DDT	1 / 7	0.042	TP111/S-1	0.015		5.0	0 / 7	390	0 / 7
TCLP Polynuclear Aromatic Hydrocarbons in mg/L (ppm)									
Napthalene	3 / 5	0.51 J	TP-207/S-1	0.114	0.303	---	---	---	---
Acenaphthylene	1 / 5	0.0023 J	TP-205/S-2	0.001		---	---	---	---
Acenaphthene	3 / 5	0.19 J	TP-207/S-1	0.049	0.117	---	---	---	---
Fluorene	3 / 5	0.096 J	TP-207/S-1	0.025	0.060	---	---	---	---
Phenanthrene	5 / 5	0.16 J	TP-207/S-1	0.043	0.100	---	---	---	---
Anthracene	5 / 5	0.019 BJ	TP-207/S-1	0.005	0.011	---	---	---	---
Fluoranthene	3 / 5	0.019 J	TP-207/S-1	0.005	0.011	---	---	---	---
Pyrene	4 / 5	0.019 J	TP-207/S-1	0.004	0.011	---	---	---	---
Benzo(a)anthracene	0 / 5	0.001 U	----			---	---	---	---
Chrysene	0 / 5	0.001 U	----			---	---	---	---
Benzo(b)fluoranthene	0 / 5	0.001 U	----			---	---	---	---
Benzo(k)fluoranthene	0 / 5	0.001 U	----			---	---	---	---
Benzo(a)pyrene	0 / 5	0.001 U	----			---	---	---	---
Dibenzo(a,h)anthracene	0 / 5	0.002 U	----			---	---	---	---
Benzo(g,h,i)perylene	0 / 5	0.001 U	----			---	---	---	---
Indeno(1,2,3-cd)pyrene	0 / 5	0.001 U	----			---	---	---	---
Miscellaneous Parameters									
in mg/kg (ppm)									
GC-FID Screen	28 / 38	1,200	TP-124/S-1	129.5	198.8	---	---	---	---
GC-FID Screen 8015 Modified	18 / 18	9,000 J	TP-207/S-1	670.7	1501.	200	9 / 18	---	---
GC-FID Screen 8015 Modified (I)	6 / 6	7,000 J	TP-207/S-1	1433.	3483.	200	6 / 6	---	---
TPH (418.1)	9 / 9	1,500 J	SS-104	578.6	829.5	200	7 / 9	---	---
Organophosphorous Pesticides	0 / 8	ND				---	---	---	---
Chlorinated Herbicides	0 / 0					---	---	---	---

Note: Data qualifiers and cross references are presented in Table 6.

Table 12 - Statistical Summary and MTCA Exceedences in Pennwalt Ag-Chem Ditch Sediment Samples

Sheet 1 of 2

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	Number of Samples Exceeding Levels/ Number Analyzed	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Number of Samples Exceeding Levels/ Number Analyzed
Total Metals									
in mg/kg (ppm)									
Arsenic	5 / 5	46	SS-1	26.7	36.6	200	0 / 5	190 (aa)	0 / 5
Cadmium	3 / 5	1.6	SS-1	0.78	1.29	10	0 / 5	1,800	0 / 5
Chromium	5 / 5	28	SS-1	17.38	23.4	500	0 / 5	18,000 (h)	0 / 5
Copper	5 / 5	75	SS-1	36.6	57.0	---	---	>>	0 / 5
Lead	5 / 5	57	PDS-A	31.4	46.9	1,000	0 / 5	---	---
Mercury	3 / 5	0.4	SS-1	0.14	0.23	1	0 / 5	1,000	0 / 5
Nickel	5 / 5	490	PDS-A	191.2	348.	---	---	70,000	0 / 5
Zinc	5 / 5	400	SS-1	147.2	268.	---	---	>>	0 / 5
Chlorinated Pesticides									
in mg/kg (ppm)	0 / 6	ND				---	---	---	---
PCBs in mg/kg (ppm)									
	0 / 5	ND				---	---	---	---
Organophosphorous Pesticides									
in mg/kg (ppm)	0 / 4	ND J				---	---	---	---
Chlorinated Herbicides									
in mg/kg (ppm)	0 / 4	ND J				---	---	---	---
Carcinogenic PAHs									
in mg/kg (ppm)	4 / 4	2.477	PDS-104-D	0.536	0.92	20	0 / 4	11	0 / 4
Non-carcinogenic PAHs									
in mg/kg (ppm)									
Acenaphthene						---	---	210,000	0 / 4
Acenaphthylene						---	---	>>	0 / 4
Anthracene						---	---	>>	0 / 4
Benzo(g,h,i)perylene						---	---	>>	0 / 4
Fluoranthene						---	---	140,000	0 / 4
Fluorene						---	---	140,000	0 / 4
2-Methylnaphthalene						---	---	>>	0 / 4
Naphthalene						---	---	14,000	0 / 4
Phenanthrene						---	---	>>	0 / 4
Pyrene						---	---	105,000	0 / 4
Total Non-carcinogenic PAHs	4 / 4	3.536	PDS-104-D	1.370	2.72	---	---	14,000 (af)	0 / 4

Table 12 - Statistical Summary and MTCA Exceedences in Pennwalt Ag-Chem Ditch Sediment Samples

Sheet 2 of 2

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (s)	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	Number of Samples Exceeding Levels/ Number Analyzed	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Number of Samples Exceeding Levels/ Number Analyzed
Miscellaneous Parameters in %									
Total Organic Carbon	3 / 3	3.8	PDS-A	2.466	3.77	---	---	---	---
Volatile Aromatic Compounds in mg/kg (ppm)									
Benzene	0 / 4	0.01 U	PDS-106-D	0.015	0.03	0.5	0 / 4	4,500	0 / 4
Toluene	3 / 4	0.039				40	0 / 4	>>	0 / 4
Ethylbenzene	0 / 4	0.01 U				20	0 / 4	>>	0 / 4
Total Xylene	0 / 4	0.01 U				20	0 / 4	>>	0 / 4
Miscellaneous Parameters in mg/kg (ppm)									
GC-FID Screen	1 / 1	103	SS-1			---	---	---	---

Note: Data qualifiers and cross references are presented in Table 6.

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Table 13 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy Ditch Sediment Samples

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method A Soil Cleanup Level - Industrial Compliance (g)	Number of Samples Exceeding Levels/ Number Analyzed	MTCA Method C Soil Cleanup Level - Industrial Direct Contact (g)	Number of Samples Exceeding Levels/ Number Analyzed
Total Metals									
in mg/kg (ppm)									
Arsenic	4 / 4	260	ODS-103B	167.	282.	200	2 / 4	190 (aa)	2 / 4
Cadmium	4 / 4	3.4	ODS-A & 103B	3.1	3.58	10	0 / 4	1,800	0 / 4
Chromium	4 / 4	250	ODS-B	125.	214.	500	0 / 4	18,000 (h)	0 / 4
Copper	4 / 4	350	ODS-103B	255	342.	---	---	>>	0 / 4
Lead	4 / 4	210	ODS-103B	145	206.	1,000	0 / 4	---	---
Mercury	0 / 4	0.1 U				1	0 / 4	1,000	0 / 4
Nickel	4 / 4	29	ODS-B	26.7	29.0	---	---	70,000	0 / 4
Zinc	4 / 4	500	ODS-103B	332.	476.	---	---	>>	0 / 4
Miscellaneous Parameters in %									
Total Organic Carbon	2 / 2	7	ODS-B	6.9	7.34	---	---	---	---
Semivolatile Organic Compounds									
in mg/kg (ppm)									
4-Methylphenol	4 / 4	3.4 J	ODS-A	2.87	3.52	---	---	>>	0 / 4
Bis(2-ethylhexyl)phthalate	3 / 4	0.38 J	ODS-103A	0.25	0.35	---	---	9,400	0 / 4
Carcinogenic PAHs									
in mg/kg (ppm)									
	4 / 4	4.84 J	ODS-103A	0.84	0.97	20	0 / 4	11	0 / 4
Non-carcinogenic PAHs									
in mg/kg (ppm)									
Acenaphthene						---	---	210,000	0 / 4
Acenaphthylene						---	---	>>	0 / 4
Anthracene						---	---	>>	0 / 4
Benzo(g,h,i)perylene						---	---	>>	0 / 4
Fluoranthene						---	---	140,000	0 / 4
Fluorene						---	---	140,000	0 / 4
2-Methylnaphthalene						---	---	>>	0 / 4
Naphthalene						---	---	14,000	0 / 4
Phenanthrene						---	---	>>	0 / 4
Pyrene						---	---	105,000	0 / 4
Total Non-carcinogenic PAHs	4 / 4	5.105 J	ODS-103A	4.51	5.36	---	---	14,000 (af)	0 / 4

Note: Data qualifiers and cross references are presented in Table 6.

Table 14 - Statistical Summary and MTCA Exceedences in Pennwalt Ag-Chem Ditch Surface Water Sample

Sample Location: Date Sampled:	SW-1/Pennwalt Jan 1990	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Total Metals			
in $\mu\text{g/L}$ (ppb)			
Antimony	10 UJ	1,040 (u)	0 / 1
Arsenic	29	2.0 (b)	1 / 1
Beryllium	1 U	1.0 (c)	0 / 1
Cadmium	9	9.3 (ac)	0 / 1
Chromium	5	50	0 / 1
Copper	20	2.9 (ac)	1 / 1
Lead	10 U	5.6 (ac)	0 / 1
Manganese	3 U	100 (ad)	0 / 1
Mercury	1 U	0.2 (e)	0 / 1
Molybdenum	50 U	---	---
Nickel	31	8.3 (ac)	1 / 1
Selenium	5 U	71 (ac)	0 / 1
Silver	1 U	2.3 (ae)	0 / 1
Thallium	5 UJ	1.5 (u)	0 / 1
Zinc	32	86 (ac)	0 / 1
Miscellaneous Parameters			
GC-FID Screen in $\mu\text{g/L}$	20	---	---
Chlorinated Herbicides in $\mu\text{g/L}$	ND	---	---
Total Suspended Solids in mg/L	8 J	---	---
Total Dissolved Solids in mg/L	1100 J	---	---

Note: Data qualifiers and cross references are presented in Table 6.

Table 15 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy Ditch Surface Water Samples

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Total Metals							
in $\mu\text{g/L}$ (ppb)							
Antimony	3 / 3	23 J	SW-2	18	24.00	1,040 (u)	0 / 3
Arsenic	3 / 3	230	SW-1	107.	256.6	2.0 (b)	3 / 3
Beryllium	0 / 3	1 U				1.0 (c)	0 / 3
Cadmium	2 / 3	21	SW-2	9.5	23.92	9.3 (ac)	1 / 3
Chromium	3 / 3	19	SW-2	10.6	20.81	50	0 / 3
Copper	3 / 3	240	SW-2	121.	262.7	2.9 (ac)	3 / 3
Lead	3 / 3	46	SW-2	21.6	51.32	5.6 (ac)	2 / 3
Manganese	1 / 3	320	SW-1			100 (ad)	1 / 3
Mercury	0 / 3	1 U				0.2 (e)	0 / 3
Molybdenum	1 / 3	12	SW-1	29	55.58	---	---
Nickel	3 / 3	15	SW-2	9.66	16.02	8.3 (ac)	1 / 3
Selenium	0 / 3	5 U				71 (ac)	0 / 3
Silver	0 / 3	1 U				2.3 (ac)	0 / 3
Thallium	0 / 3	5 U				1.5 (u)	0 / 3
Zinc	3 / 3	150	SW-2	92.3	162.5	86 (ac)	1 / 3
Dissolved Metals							
in $\mu\text{g/L}$ (ppb)							
Antimony	1 / 1	15	SW-1			1,040 (u)	0 / 1
Arsenic	1 / 1	180	SW-1			2.0 (b)	1 / 1
Beryllium	0 / 1	1 U				1.0 (c)	0 / 1
Cadmium	0 / 1	1 U				9.3 (ac)	0 / 1
Chromium	1 / 1	3	SW-1			50	0 / 1
Copper	1 / 1	42	SW-1			2.9 (ac)	1 / 1
Lead	1 / 1	6.9	SW-1			5.6 (ac)	1 / 1
Manganese	1 / 1	310	SW-1			100 (ad)	1 / 1
Mercury	0 / 1	1 U				0.2 (e)	0 / 1
Molybdenum	1 / 1	12	SW-1			---	---
Nickel	1 / 1	6	SW-1			8.3 (ac)	0 / 1
Selenium	0 / 1	5 U				71 (ac)	0 / 1
Silver	0 / 1	1 U				2.3 (ac)	0 / 1
Thallium	0 / 1	2 U				1.5 (u)	0 / 1
Zinc	1 / 1	62	SW-1			86 (ac)	0 / 1
Miscellaneous Parameters							
Hardness as CaCO_3 in mg/L	1 / 1	38	SW-1			---	---
Total Suspended Solids in mg/L	3 / 3	87 J	SW-2	42	95.85	---	---
Total Dissolved Solids in mg/L	2 / 2	690 J	SW-2	470	1452.	---	---

Note: Data qualifiers and cross references are presented in Table 6.

Table 16 - Summary of Surface Water Regulatory Criteria Used to Establish MTCA Marine Surface Water Cleanup Levels

Sheet 1 of 2

	MTCA Method B Surface Water Non-carcinogenic Cleanup Levels (u)	MTCA Method B Surface Water Carcinogenic Cleanup Levels (v)	Clean Water Act		Fish Ingestion (10E-06)	Most Stringent Level Used for MTCA Method B Surface Water Cleanup Levels (g)
			Marine Acute	Marine Chronic		
Metals in $\mu\text{g/L}$ (ppb)						
Antimony	1,040	---	---	---	4,300	1,040 (u)
Arsenic	59	0.08	69	36	0.14	2.0 (b)
Barium	>100,000	---	>50,000 (w)	>50,000 (w)	---	>50,000 (ac)
Beryllium	680	0.08	---	---	0.13	1.0 (c)
Cadmium	41 (x)	---	43	9.3	---	9.3 (ac)
Chromium	810 (y)	---	1,100 (d)	50 (d)	>100,000 (t)	50
Copper	2,675	---	2.9	2.9	---	2.9 (ac)
Iron	---	---	---	---	---	---
Lead	---	---	140	5.6	---	5.6 (ac)
Manganese	---	---	---	---	100	100 (ad)
Mercury	0.2 (z)	---	2.1	0.025	0.153	0.2 (c)
Molybdenum	---	---	---	---	---	---
Nickel	1,103	---	75	8.3	4,500	8.3 (ac)
Selenium	---	---	300	71	---	71 (ac)
Silver	15,600	---	2.3	---	---	2.3 (ac)
Thallium	1.5	---	2,130 (w)	---	48	1.5 (u)
Zinc	11,032	---	95	86	---	86 (ac)
Semivolatile Organic Compounds in $\mu\text{g/L}$ (ppb)						
Benzoic acid	---	---	---	---	---	---
Bis(2-ethylhexyl)phthalate	---	3.6	---	---	5.9	3.6 (v)
Dibenzofuran	---	---	---	---	---	---
Di-n-octyl phthalate	---	---	---	---	---	---
4-Methylphenol	---	---	---	---	---	---
Phenol	1,110,000	---	5,800 (w)	---	---	5,800 (ac)

Table 16 - Summary of Surface Water Regulatory Criteria Used to Establish MTCA Marine Surface Water Cleanup Levels

Sheet 2 of 2

	MTCA Method B Surface Water Non-carcinogenic Cleanup Levels (u)	MTCA Method B Surface Water Carcinogenic Cleanup Levels (v)	Clean Water Act		Fish Ingestion (10E-06)	Most Stringent Level Used for MTCA Method B Surface Water Cleanup Levels (g)
			Marine Acute	Marine Chronic		
Volatile Organic Compounds						
in µg/L (ppb)						
Acetone	---	---	---	---	---	---
Benzene	---	43	5,100 (w)	700 (w)	71	43 (v)
cis-1,2-dichloroethylene	---	---	224,000 (w)	---	---	---
trans-1,2-dichloroethylene	4,850	---	224,000 (w)	---	---	4,850 (u)
Ethylbenzene	6,900	---	430 (w)	---	28,700	430 (ac)
Formaldehyde	---	---	---	---	---	21.6
Tetrachloroethene	850	4.1	10,200 (w)	450 (w)	8.9	4.1 (v)
Methylene Chloride	173,000	960	---	---	1,578	960 (u)
Toluene	48,500	---	6,300 (w)	5,000 (w)	200,000	5,000 (ac)
Trichloroethene	---	56	---	---	81	56 (v)
Vinyl chloride	---	2.9	---	---	525	2.9 (v)
Xylenes	>>	---	---	---	---	>> (u)
Non-carcinogenic PAHs						
in µg/L (ppb)						
Acenaphthene	643	---	970 (w)	710 (w)	---	643 (u)
Acenaphthylene	---	---	---	---	---	---
Anthracene	---	---	---	---	107,700	107,700 (ad)
Fluoranthene	90	---	---	---	375	90 (u)
Fluorene	---	---	---	---	14,360	14,360 (ad)
Naphthalene	988	---	2,350 (w)	---	---	1,000 (u)
Phenanthrene	---	---	---	---	---	---
Pyrene	---	---	---	---	10,770	10,770 (ad)
Carcinogenic PAHs						
in µg/L (ppb)						
as Benzo(a)pyrene	---	0.02	300 (w)	---	0.03	0.02 (f,v)

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Note: Data qualifiers and cross references are presented in Table 6.

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Table 17 - Statistical Summary and MTCA Exceedences in General/Fill Area Shallow Groundwater Samples

Sheet 1 of 2

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Dissolved Metals in $\mu\text{g/L}$ (ppb)							
Antimony	2 / 14	17 J	HC-14S	6.5	8.2596	1,040 (u)	0 / 14
Arsenic	2 / 14	11	HC-1S	3.357	4.4469	2.0 (b)	2 / 14
Beryllium	0 / 7	10 U	---	---	---	1.0 (c)	0 / 7
Cadmium	5 / 14	25	HC-13S	8.285	11.882	9.3 (ac)	3 / 14
Chromium	4 / 14	8.0	HC-13S	3.75	4.7844	50	0 / 14
Copper	7 / 14	21	HC-13S	7.464	9.9114	2.9 (ac)	7 / 14
Iron	7 / 7	170,000 BJ	HC-13S	80658	130595	---	---
Lead	0 / 14	3 U	---	---	---	5.6 (ac)	0 / 14
Manganese	13 / 14	16,000	HC-13S	3180.	5725.1	100 (ad)	12 / 14
Mercury	0 / 14	1 U	---	---	---	0.2 (e)	0 / 14
Molybdenum	0 / 2	500 U	---	---	---	---	---
Nickel	10 / 14	640	HC-13S	161.6	262.93	8.3 (ac)	10 / 14
Selenium	0 / 7	5 U	---	---	---	71 (ac)	0 / 7
Silver	1 / 14	1 J	HC-1S	2.785	---	2.3 (ae)	0 / 14
Thallium	0 / 7	5 U	---	---	---	1.5 (u)	0 / 7
Zinc	13 / 14	680	HC-2S	178	260.84	86 (ac)	8 / 14
Volatile Organic Compounds in $\mu\text{g/L}$ (ppb)							
Vinyl chloride	0 / 14	1 U	---	---	---	2.9 (v)	0 / 14
Methylene chloride	0 / 14	1 U	---	---	---	960 (u)	0 / 14
Acetone	1 / 14	57	HC-1S	6.392	---	---	---
trans-1,2-Dichloroethene	0 / 14	1 U	---	---	---	4,850 (u)	0 / 14
cis-1,2-Dichloroethene	0 / 14	1 U	---	---	---	---	---
Total 1,2-Dichloroethene	0 / 14	1 U	---	---	---	---	---
2-Butanone (MEK)	0 / 14	3 U	---	---	---	---	---
Trichloroethene	0 / 14	1 U	---	---	---	56 (v)	0 / 14
Benzene	0 / 14	1 U	---	---	---	43 (v)	0 / 14
Toluene	1 / 14	1	HC-13S	0.535	---	5,000 (ac)	0 / 14
Ethylbenzene	0 / 14	1 U	---	---	---	430 (ac)	0 / 14
Total Xylene	0 / 14	1 U	---	---	---	>> (u)	0 / 14
Miscellaneous Parameters in mg/L (ppb)							
Total Dissolved Solids	14 / 14	4800	HC-13S	1785	2526.9	---	---
Total Suspended Solids	7 / 7	630	HC-2S	216.5	353.77	---	---
Fluoride	7 / 7	6.8	HC-17S	2.271	3.7076	---	---
Hardness as CaCO_3	7 / 7	1400	HC-13S	554.2	908.11	---	---

Table 17 - Statistical Summary and MTCA Exceedences in General/Fill Area Shallow Groundwater Samples

Sheet 2 of 2

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Miscellaneous Parameters in µg/L (ppb)							
Formaldehyde	5 / 7	260	HC-13S	49.11	113.21	---	---
Semivolatile Organic Compounds in µg/L (ppb)							
Phenol	0 / 10	3 U	----			5,800 (ac)	0 / 10
4-Methylphenol	0 / 10	3 U	----			---	---
Benzoic acid	0 / 10	67 U	----			---	---
Dibenzofuran	0 / 9	2 U	----			---	---
Bis(2-ethylhexyl)phthalate	2 / 10	10 J	HC-14S	3.055	4.8101	3.6 (v)	2 / 10
Di-n-octyl phthalate	0 / 10	2 U	----			---	---
Carcinogenic PAHs in µg/L (ppb)	0 / 9	24 U	----			0.02 (f,v)	0 / 9
Non-carcinogenic PAHs in µg/L (ppb)							
Acenaphthene						643 (u)	0 / 9
Acenaphthylene						---	---
Anthracene						107,700 (ad)	0 / 9
Benzo(g,h,i)perylene						---	---
Fluoranthene						90 (u)	0 / 9
Fluorene						14,360 (ad)	0 / 9
2-Methylnaphthalene						---	---
Naphthalene						1,000 (u)	0 / 9
Phenanthrene						---	---
Pyrene						10,770 (ad)	0 / 9
Total Non-carcinogenic PAHs	0 / 9	24 U	----			---	---
Field Parameters							
pH	13 / 13	8.5	HC-18S	6.138	6.6449	---	---
Temperature in °C	14 / 14	13	HC-13S	10.34	11.097	---	---
Specific Conductivity in µMhos	14 / 14	4100	HC-13S	1746.	2373.7	---	---
Dissolved Oxygen in ppm	8 / 8	9.8	HC-2S	4.225	5.8297	---	---
Chlorinated Pesticides in µg/L (ppb)	0 / 7	ND	----			---	---
PCBs in µg/L (ppb)	0 / 7	ND	----			---	---

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Note: Data qualifiers and cross references are presented in Table 6.

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Table 18 - Statistical Summary and MTCA Exceedences in North Site Area Shallow Groundwater Samples

Sheet 1 of 2

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Dissolved Metals							
in µg/L (ppb)							
Antimony	3 / 9	41	HC-9S	8.5	15.65	1,040 (u)	0 / 9
Arsenic	5 / 9	92	HC-9S	32	50.79	2.0 (b)	5 / 9
Beryllium	0 / 5	1 U	----			1.0 (c)	0 / 5
Cadmium	4 / 9	2 J	HC-7S	0.83	1.125	9.3 (ac)	0 / 9
Chromium	3 / 9	2	HC-7S	0.92	1.217	50	0 / 9
Copper	2 / 9	2	HC-9S & HC-21S	0.83	1.219	2.9 (ac)	0 / 9
Iron	4 / 4	15,000 B	HC-7S	6437	13156	---	---
Lead	1 / 9	3.6	HC-7S	1.67		5.6 (ac)	0 / 9
Manganese	6 / 6	580	HC-8S	433.	549.2	100 (ad)	6 / 6
Mercury	0 / 9	1 U	----			0.2 (e)	0 / 9
Molybdenum	0 / 2	50 U	----			---	---
Nickel	4 / 9	50	HC-8S	10.8	20.50	8.3 (ac)	3 / 9
Selenium	0 / 5	5 U	----			71 (ac)	0 / 5
Silver	0 / 9	1 U	----			2.3 (ac)	0 / 9
Thallium	0 / 5	5 U	----			1.5 (u)	0 / 5
Zinc	6 / 9	110	HC-9S	22.0	41.89	86 (ac)	1 / 9
Volatile Organic Compounds							
in µg/L (ppb)							
Vinyl chloride	10 / 10	85	HC-7S	35.6	50.51	2.9 (v)	10 / 10
Methylene chloride	0 / 10	1 U	----			960 (u)	0 / 10
Acetone	0 / 10	5 U	----			---	---
trans-1,2-Dichloroethene	4 / 10	2	HC-8S & HC-21S	1	1.388	4,850 (u)	0 / 10
cis-1,2-Dichloroethene	5 / 10	5	HC-8S	1.45	2.274	---	---
Total 1,2-Dichloroethene	6 / 10	8	HC-8S	2.2	3.626	---	---
2-Butanone (MEK)	0 / 10	3 U	----			---	---
Trichloroethene	0 / 10	1 U	----			56 (v)	0 / 10
Benzene	0 / 10	1 U	----			43 (v)	0 / 10
Toluene	0 / 10	1 U	----			5,000 (ac)	0 / 10
Ethylbenzene	0 / 10	1 U	----			430 (ac)	0 / 10
Total Xylene	0 / 10	1 U	----			>> (u)	0 / 10
Miscellaneous Parameters							
in mg/L (ppm)							
Total Dissolved Solids	10 / 10	1,200	HC-21S	722	911.9	---	---
Total Suspended Solids	8 / 8	1,800 J	HC-21S	761.	1174.	---	---
Fluoride	4 / 4	8.6	HC-21S	4.88	8.065	---	---
Hardness as CaCO ₃	4 / 4	610	HC-21S	335	574.4	---	---

Table 18 - Statistical Summary and MTCA Exceedences in North Site Area Shallow Groundwater Samples

Sheet 2 of 2

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Miscellaneous Parameters in $\mu\text{g/L}$ (ppb)							
Formaldehyde	4 / 4	25	HC-7S	10.5	21.35	---	---
Semivolatile Organic Compounds in $\mu\text{g/L}$ (ppb)							
Phenol	0 / 6	2 U	---			5,800 (ac)	0 / 6
4-Methylphenol	0 / 6	2 U	---			---	---
Benzoic acid	0 / 6	51 U	---			---	---
Dibenzofuran	0 / 6	2 U	---			---	---
Bis(2-ethylhexyl)phthalate	0 / 6	6.5 U	---			3.6 (v)	0 / 6
Di-n-octyl phthalate	0 / 6	2 U	---			---	---
Carcinogenic PAHs in $\mu\text{g/L}$ (ppb)	6 / 10	16.1	HC-21S	2.47	3.408	0.02 (f,v)	6 / 10
Non-carcinogenic PAHs in $\mu\text{g/L}$ (ppb)							
Acenaphthene						643 (u)	0 / 10
Acenaphthylene						---	---
Anthracene						107,700 (ad)	0 / 10
Benzo(g,h,i)perylene						---	---
Fluoranthene						90 (u)	0 / 10
Fluorene						14,360 (ad)	0 / 10
2-Methylnaphthalene						---	---
Naphthalene						1,000 (u)	0 / 10
Phenanthrene						---	---
Pyrene						10,770 (ad)	0 / 10
Total Non-carcinogenic PAHs	6 / 10	88.1	HC-21S	21.5	34.74	---	---
Field Parameters							
pH	8 / 8	7.3	HC-8S	6.95	7.099	---	---
Temperature in $^{\circ}\text{C}$	10 / 10	18.4	HC-7S	12.4	14.70	---	---
Specific Conductivity in μMhos	10 / 10	1,800	HC-7S	1107	1408.	---	---
Dissolved Oxygen in ppm	10 / 10	4.3	HC-21S	2.97	3.481	---	---
Chlorinated Pesticides in $\mu\text{g/L}$ (ppb)	0 / 2	ND	---			---	---
PCBs in $\mu\text{g/L}$ (ppb)	0 / 2	ND	---			---	---

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Note: Data qualifiers and cross references are presented in Table 6.

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Table 19 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy/Pennwalt Area Shallow Groundwater Samples

Sheet 1 of 3

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Dissolved Metals							
in µg/L (ppb)							
Antimony	8 / 26	25 J	HC-6S	6.642	8.0566	1,040 (u)	0 / 26
Arsenic	19 / 26	640	HC-6S	126.8	185.75	2.0 (b)	19 / 26
Arsenic (+3)	5 / 5	275	HC-6S	84.34	177.18	—	—
Arsenic (+5)	5 / 5	87	HC-4S	48.42	79.115	—	—
Beryllium	1 / 14	3.3	HC-5S	3.271		1.0 (c)	1 / 14
Cadmium	7 / 26	6 / 6 J	HC-10S & EPA-7S	2.913	3.6663	9.3 (ac)	0 / 26
Chromium	18 / 26	190	HC-4S	43.38	62.874	50	8 / 26
Chromium (+6)	0 / 0					—	—
Copper	14 / 26	160	EPA-9S	23.59	37.111	2.9 (ac)	14 / 26
Iron	10 / 12	72,000	HC-10S	16397	27810.	—	—
Lead	11 / 26	100	HC-4S	14.80	23.394	5.6 (ac)	8 / 26
Manganese	22 / 22	20,000	HC-16S	2102.	3661.5	100 (ad)	18 / 22
Mercury	0 / 26	1.5 U	—			0.2 (e)	0 / 26
Nickel	13 / 26	120	HC-4S	15.48	24.102	8.3 (ac)	12 / 26
Selenium	0 / 14	5 U	—			71 (ac)	0 / 14
Silver	3 / 26	4	HC-5S	2.259	2.9401	2.3 (ac)	3 / 26
Thallium	0 / 14	5 U	—			1.5 (u)	0 / 14
Zinc	22 / 26	110 J	HC-25S	32.69	42.886	86 (ac)	2 / 26
Volatile Organic Compounds							
in µg/L (ppb)							
Vinyl chloride	0 / 27	5 U	—			2.9 (v)	0 / 27
Methylene chloride	0 / 27	5 U	—			960 (u)	0 / 27
Acetone	7 / 27	74	HC-4S	9.259	14.584	—	—
trans-1,2-Dichloroethene	0 / 27	5 U	—			4,850 (u)	0 / 27
cis-1,2-Dichloroethene	0 / 27	5 U	—			—	—
Total 1,2-Dichloroethene	0 / 27	5 U	—			—	—
2-Butanone (MEK)	0 / 27	15 U	—			—	—
Trichloroethene	0 / 27	5 U	—			56 (v)	0 / 27
Benzene	8 / 27	50	HC-4S	6.907	11.204	43 (v)	1 / 27
Tetrachloroethene	1 / 27	1 J	HC-6S	0.842		4.1 (v)	0 / 27
Toluene	7 / 27	72	HC-4S	8.185	14.878	5,000 (ac)	0 / 27
Ethylbenzene	3 / 27	14	HC-4S	1.990	3.2780	430 (ac)	0 / 27
Total Xylene	3 / 27	93	HC-4S	9.175	17.239	>> (u)	0 / 27

Table 19 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy/Pennwalt Area Shallow Groundwater Samples

Sheet 2 of 3

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Miscellaneous Parameters in µg/L (ppb)							
Formaldehyde	11 / 12	190	EPA-9S	55.83	83.526	—	—
Miscellaneous Parameters in mg/L (ppm)							
Total Dissolved Solids	27 / 27	13,000 J	HC-4S	2872.	3925.7	—	—
Total Suspended Solids	17 / 17	1,100 J	HC-6S	330.2	457.60	—	—
Fluoride	12 / 12	7.8	HC-12S	3.595	4.5760	—	—
Hardness as CaCO ₃	12 / 12	750	HC-15S	249.5	369.67	—	—
Calcium	4 / 4	78	HC-11S	30.07	63.253	—	—
Chloride	4 / 4	2,400 J	HC-5S	889.2	1942.4	—	—
Hydrogen Sulfide as S	3 / 3	23 J	HC-4S	14.6	24.647	—	—
Magnesium	4 / 4	51	HC-11S	16.47	40.109	—	—
Sodium	4 / 4	2,300	HC-5S	1475	2410.2	—	—
Sulfate as SO ₄	4 / 4	38 J	HC-4S	21.25	37.560	—	—
Total Alkalinity as CaCO ₃	4 / 4	3,500	HC-4S	1915	3046.9	—	—
Semivolatile Organic Compounds in µg/L (ppb)							
Phenol	2 / 18	83	HC-4S	10.5	20.630	5,800 (ac)	0 / 18
4-Methylphenol	4 / 18	38	HC-11S	6.972	11.600	—	—
Benzoic acid	1 / 18	92	HC-11S	54.02	—	—	—
Dibenzofuran	0 / 22	20 U	—	—	—	—	—
Bis(2-ethylhexyl)phthalate	4 / 22	110 B	EPA-9S	9.636	17.868	3.6 (v)	4 / 22
Di-n-octyl phthalate	0 / 22	20 U	—	—	—	—	—
Non-carcinogenic PAHs in µg/L (ppb)							
Acenaphthene	—	—	—	—	—	643 (u)	0 / 27
Acenaphthylene	—	—	—	—	—	—	—
Anthracene	—	—	—	—	—	107,700 (ad)	0 / 27
Benzo(g,h,i)perylene	—	—	—	—	—	—	—
Fluoranthene	—	—	—	—	—	90 (u)	0 / 27
Fluorene	—	—	—	—	—	14,360 (ad)	0 / 27
2-Methylnaphthalene	—	—	—	—	—	—	—
Naphthalene	—	—	—	—	—	1,000 (u)	0 / 27
Phenanthrene	—	—	—	—	—	—	—
Pyrene	—	—	—	—	—	10,770 (ad)	0 / 27
Total Non-carcinogenic PAHs	12 / 27	1,045	EPA-9S	139.7	236.66	—	—

Table 19 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy/Pennwalt Area Shallow Groundwater Samples

Sheet 3 of 3

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Carcinogenic PAHs in $\mu\text{g/L}$ (ppb)	9 / 27	77.7 J	HC-11S	6.490	8.7749	0.02 (f,v)	9 / 27
Field Parameters							
pH	25 / 25	11.1	HC-4S	8.132	8.5775	---	---
Temperature in $^{\circ}\text{C}$	27 / 27	20.1	HC-5S	11.33	12.442	---	---
Specific Conductivity in μMhos	27 / 27	13,300	HC-4S	4084.	5350.1	---	---
Dissolved Oxygen in ppm	23 / 23	10.3	HC-16S	3.526	4.4030	---	---
Organophosphorous Pesticides in $\mu\text{g/L}$ (ppb)	0 / 2	ND	----			---	---
Chlorinated Pesticides in $\mu\text{g/L}$ (ppb)	0 / 13	ND	----			---	---
PCBs in $\mu\text{g/L}$ (ppb)	0 / 13	ND	----			---	---
Chlorinated Herbicides in $\mu\text{g/L}$ (ppb)							
2,4-DB	1 / 3	9	EPA-9S	6	9.5762	---	---
Dinoseb	3 / 3	5	HC-4S	3.666	5.7693	---	---

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Note: Data qualifiers and cross references are presented in Table 6.

Table 20 - Comparison of Shallow Groundwater Metal Concentrations to Regional Surface Water and Groundwater Quality Data

	General/Fill Area average concentration	North Site Area average concentration	Ohio Ferro- Alloy/Pennwalt Area average concentration	Residential Stormwater Runoff (m) average concentration	Puyallup River (n) average concentration	Reichhold S Ditch (o) average concentration	Upper 95th Confidence Limit of the Mean Port of Tacoma Groundwater Reference Samples	MTCA Method B Surface Water Cleanup Levels (g)
Metals								
in µg/L (ppb)								
Antimony	6.5	8.5	6.6	ND	---	ND	7	1,040 (u)
Arsenic	3.4	32	127	13	4	7.8	5	2.0 (b)
Beryllium	ND	ND	3.3	ND	---	1	---	1.0 (c)
Cadmium	8.3	0.8	2.9	0.7	2.5	ND	10	9.3 (ac)
Chromium	3.8	0.9	43	8	9.3	ND	12	50
Copper	7.5	0.8	24	20	70	23	19	2.9 (ac)
Iron	80,700	6,400	16,400	---	---	12,100	---	---
Lead	ND	1.7	15	210	9.3	3.9	1.5	5.6 (ac)
Manganese	3,180	430	2,100	---	---	1,440	4,570	100 (ad)
Mercury	ND	ND	ND	ND	0.07	---	---	0.2 (e)
Molybdenum	ND	ND	---	---	---	---	---	---
Nickel	162	11	15	12	16	93	10	8.3 (ac)
Selenium	ND	ND	ND	ND	---	ND	---	71 (ac)
Silver	2.8	ND	2.3	ND	ND	ND	---	2.3 (ae)
Thallium	ND	ND	ND	ND	---	ND	---	1.5 (u)
Zinc	178	22	33	115	77	163	60	86 (ac)

Notes:

Groundwater concentrations are reported on dissolved basis. Residential Stormwater, Puyallup River, and Reichhold Ditch surface water data are reported on a total non-filtered basis.

Data qualifiers and cross references are presented in Table 6.

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Table 21 - Statistical Summary and MTCA Exceedences in General/Fill Area Intermediate Groundwater Samples

Sheet 1 of 2

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Dissolved Metals (k) in µg/L (ppb)							
Antimony	1 / 10	11	HC-2I	5.6		1,040 (u)	0 / 10
Arsenic	2 / 12	3.5 J	MW-29I	2.566	2.715	2.0 (b)	2 / 12
Barium	2 / 2	143 J	MW-28I	78.65	365.9	>50,000 (ac)	0 / 2
Beryllium	0 / 5	10.0 U	----			1.0 (c)	0 / 5
Cadmium	2 / 12	5.4	HC-14I	3.241	4.254	9.3 (ac)	0 / 12
Chromium	6 / 12	20.4	MW-29I	6.733	9.206	50	0 / 12
Copper	1 / 10	1.0	HC-3I	2.8	4.077	2.9 (ac)	0 / 10
Iron	5 / 5	29,000 BJ	HC-14I	13680	23829	----	----
Lead	1 / 12	6.4	HC-17I	2.908	3.979	5.6 (ac)	1 / 12
Manganese	12 / 12	2,300	HC-13I	930.8	1287.	100 (ad)	12 / 12
Mercury	0 / 10	1 U	----			0.2 (e)	0 / 10
Molybdenum	3 / 5	5648	MW-29I	2348.	4918.	----	----
Nickel	0 / 12	41.6 U	----			8.3 (ac)	0 / 12
Selenium	0 / 5	5 U	----			71 (ac)	0 / 5
Silver	1 / 10	5.0 J	HC-14I	3.2		2.3 (ac)	1 / 10
Thallium	0 / 5	5 U	----			1.5 (u)	0 / 5
Zinc	9 / 12	94 B	HC-14I	33.72	48.88	86 (ac)	2 / 12
Volatile Organic Compounds in µg/L (ppb)							
Vinyl chloride	0 / 16	10 U	----			2.9 (v)	0 / 16
Methylene chloride	0 / 12	5 U	----			960 (u)	0 / 12
Acetone	2 / 14	14 J	HC-13I	4.232	5.634	----	----
trans-1,2-Dichloroethene	0 / 16	5 U	----			4,850 (u)	0 / 16
cis-1,2-Dichloroethene	0 / 10	1 U	----			----	----
Total 1,2-Dichloroethene	0 / 12	5 U	----			----	----
2-Butanone (MEK)	0 / 12	10 U	----			----	----
Trichloroethene	0 / 16	5 U	----			56 (v)	0 / 16
Benzene	0 / 16	5 U	----			43 (v)	0 / 16
Toluene	6 / 14	9	HC-17I	2.232	3.214	5,000 (ac)	0 / 14
Ethylbenzene	0 / 14	5 U	----			430 (ac)	0 / 14
Total Xylene	0 / 12	5 U	----			>> (u)	0 / 12
Miscellaneous Parameters in µg/L (ppb)							
Formaldehyde	2 / 11	33	HC-13I	19.5	25.70	----	----

Table 21 - Statistical Summary and MTCA Exceedences in General/Fill Area Intermediate Groundwater Samples

Sheet 2 of 2

	Detection Frequency	Maximum Detection	Location of Maximum	Upper 95th Confidence Limit Average of the Mean (a)		MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Miscellaneous Parameters in mg/L (ppb)							
Total Dissolved Solids	9 / 9	16,000	HC-2I	11688	13468	---	---
Total Suspended Solids	4 / 4	680	HC-17I	377.5	655.4	---	---
Fluoride	4 / 4	0.7	HC-14I	0.575	0.703	---	---
Semivolatile Organic Compounds in µg/L (ppb)							
Phenol	0 / 11	10 U	---			5,800 (ac)	0 / 11
4-Methylphenol	0 / 15	10 U	---			---	---
Benzoic acid	0 / 11	51 U	---			---	---
Dibenzofuran	1 / 11	1	HC-17I	1.681		---	---
Bis(2-ethylhexyl)phthalate	3 / 13	10 B	MW-28I	4.153	6.004	3.6 (v)	3 / 13
Di-n-octyl phthalate	0 / 15	10 U	---			---	---
Carcinogenic PAHs in µg/L (ppb)							
	0 / 11	70 U	---			0.02 (f,v)	0 / 11
Non-carcinogenic PAHs in µg/L (ppb)							
Acenaphthene						643 (u)	0 / 11
Acenaphthylene						---	---
Anthracene						107,700 (ad)	0 / 11
Benzo(g,h,i)perylene						---	---
Fluoranthene						90 (u)	0 / 11
Fluorene						14,360 (ad)	0 / 11
2-Methylnaphthalene						---	---
Naphthalene						1,000 (u)	0 / 11
Phenanthrene						---	---
Pyrene						10,770 (ad)	0 / 11
Total Non-carcinogenic PAHs	1 / 11	9	HC-17I	15.69		---	---
Field Parameters							
pH	9 / 9	7.1	HC-2I	6.588	6.839	---	---
Temperature in °C	10 / 10	12	HC-2I	10.29	11.12	---	---
Specific Conductivity in µMhos	10 / 10	19,650	HC-2I	13751	16569	---	---
Dissolved Oxygen in ppm	5 / 5	10.5	HC-13I	5.5	8.071	---	---
Chlorinated Pesticides in µg/L (ppb)							
	0 / 5	ND	---			---	---
PCBs in µg/L (ppb)							
	0 / 7	ND	---			---	---

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Note: Data qualifiers and cross references are presented in Table 6.

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Table 22 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy/Pennwalt Area Intermediate Groundwater Samples

Sheet 1 of 3

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Dissolved Metals							
in $\mu\text{g/L}$ (ppb)							
Antimony	0 / 22	20 U	----			1,040 (u)	0 / 22
Arsenic	0 / 22	5 U	----			2.0 (b)	0 / 22
Beryllium	0 / 13	10 U	----			1.0 (c)	0 / 13
Cadmium	1 / 22	1.0	HC-12I	2.363		9.3 (ac)	0 / 22
Chromium	15 / 22	21	EPA-10I	10.18	12.11	50	0 / 22
Copper	4 / 22	15	HC-4I	3.477	4.767	2.9 (ac)	4 / 22
Iron	9 / 9	9,000	HC-12I	3500	4894.	----	----
Lead	2 / 22	50	HC-4I	6.231	11.32	5.6 (ac)	2 / 22
Manganese	18 / 18	1,400	HC-12I	353.8	491.0	100 (ad)	18 / 18
Mercury	0 / 22	2 U	----			0.2 (c)	0 / 22
Nickel	1 / 22	5.4	HC-4I	4.881		8.3 (ac)	0 / 22
Selenium	0 / 13	5 U	----			71 (ac)	0 / 13
Silver	0 / 22	10 U	----			2.3 (ac)	0 / 22
Thallium	0 / 13	5 U	----			1.5 (u)	0 / 13
Zinc	15 / 22	160 B	HC-4I	27.98	40.79	86 (ac)	2 / 22
Volatile Organic Compounds							
in $\mu\text{g/L}$ (ppb)							
Vinyl chloride	0 / 22	1 U	----			2.9 (v)	0 / 22
Methylene chloride	0 / 22	1 U	----			960 (u)	0 / 22
Acetone	4 / 22	30 J	EPA-6I	4.681	6.889	----	----
trans-1,2-Dichloroethene	0 / 22	1 U	----			4,850 (u)	0 / 22
cis-1,2-Dichloroethene	0 / 22	1 U	----			----	----
Total 1,2-Dichloroethene	0 / 22	1 U	----			----	----
2-Butanone (MEK)	0 / 22	3 U	----			----	----
Trichloroethene	0 / 22	1 U	----			56 (v)	0 / 22
Benzene	0 / 22	1 U	----			43 (v)	0 / 22
Tetrachloroethene	0 / 22	1 U	----			4.1 (v)	0 / 22
Toluene	5 / 22	3	HC-6I	0.886	1.156	5,000 (ac)	0 / 22
Ethylbenzene	0 / 22	1 U	----			430 (ac)	0 / 22
Total Xylene	0 / 22	1 U	----			>> (u)	0 / 22

Table 22 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy/Pennwalt Area Intermediate Groundwater Samples

Sheet 2 of 3

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Miscellaneous Parameters							
in µg/L (ppb)							
Formaldehyde	5 / 9	27	HC-121	10.56	16.12	—	—
Miscellaneous Parameters							
in mg/L (ppm)							
Total Dissolved Solids	22 / 22	13,000 J	HC-121	8804	9697	—	—
Total Suspended Solids	13 / 13	1,900	HC-161	365.4	612.6	—	—
Fluoride	9 / 9	1.2	HC-101	0.788	0.914	—	—
Hardness as CaCO ₃	1 / 1	1,000	EPA-101	1000		—	—
Semivolatile Organic Compounds							
in µg/L (ppb)							
Phenol	0 / 18	6 U	—			5,800 (ac)	0 / 18
4-Methylphenol	0 / 18	3 U	—			—	—
Benzoic acid	0 / 18	67 U	—			—	—
Dibenzofuran	0 / 18	3 U	—			—	—
Bis(2-ethylhexyl)phthalate	3 / 18	6 J	HC-101	3.027	4.345	3.6 (v)	3 / 18
Di-n-octyl phthalate	0 / 18	3 U	—			—	—
Carcinogenic PAHs							
in µg/L (ppb)							
	2 / 22	6.22	EPA-81	2.806	3.568	0.02 (f,v)	2 / 22
Non-carcinogenic PAHs							
in µg/L (ppb)							
Acenaphthene						643 (u)	0 / 22
Acenaphthylene						—	—
Anthracene						107,700 (ad)	0 / 22
Benzo(g,h,i)perylene						—	—
Fluoranthene						90 (u)	0 / 22
Fluorene						14,360 (ad)	0 / 22
2-Methylnaphthalene						—	—
Naphthalene						1,000 (u)	0 / 22
Phenanthrene						—	—
Pyrene						10,770 (ad)	0 / 22
Total Non-carcinogenic PAHs	5 / 22	34	EPA-81	11.93	14.99	—	—

Table 22 - Statistical Summary and MTCA Exceedences in Ohio Ferro-Alloy/Pennwalt Area Intermediate Groundwater Samples

Sheet 3 of 3

	Detection Frequency	Maximum Detection	Location of Maximum	Average	Upper 95th Confidence Limit of the Mean (a)	MTCA Method B Surface Water Cleanup Levels (g)	Number of Samples Exceeding Levels/ Number Analyzed
Field Parameters							
pH	19 / 19	7.2	HC-12I	6.826	6.938	---	---
Temperature in °C	22 / 22	17	HC-4I	12.12	12.80	---	---
Specific Conductivity in μ Mhos	22 / 22	17,700	HC-12I	11355	13018	---	---
Dissolved Oxygen in ppm	18 / 18	6.6	HC-6I	3.966	4.551	---	---
Chlorinated Pesticides							
in μ g/L (ppb)	0 / 8	ND	----			---	---
PCBs in μg/L (ppb)							
	0 / 8	ND	----			---	---

OFAQWL.WX1

Note: Data qualifiers and cross references are presented in Table 6.

Table 23 - Comparison of Intermediate Groundwater Metal Concentrations to Regional Surface Water and Groundwater Quality Data

	General/Fill Area average concentration	Ohio Ferro- Alloy/Pennwalt Area average concentration	Residential Stormwater Runoff (m) average concentration	Puyallup River (n) average concentration	Reichhold S Ditch (o) average concentration	Upper 95th Confidence Limit of the Mean Port of Tacoma Groundwater Reference Samples	MTCA Method B Surface Water Cleanup Levels (g)
Metals							
in $\mu\text{g/L}$ (ppb)							
Antimony	5.6	ND	ND	---	ND	7	1,040 (u)
Arsenic	2.6	ND	13	4	7.8	5	2.0 (b)
Beryllium	ND	ND	ND	---	1	---	1.0 (c)
Cadmium	3.2	2.4	0.7	2.5	ND	10	9.3 (ac)
Chromium	6.7	10	8	9.3	ND	12	50
Copper	2.8	3.5	20	70	23	19	2.9 (ac)
Iron	14,000	3,500	---	---	12,100	---	---
Lead	2.9	6.2	210	9.3	3.9	1.5	5.6 (ac)
Manganese	930	350	---	---	1,440	4,570	100 (ad)
Mercury	ND	ND	ND	0.07	---	---	0.2 (e)
Molybdenum	2,300	---	---	---	---	---	---
Nickel	ND	4.9	12	16	93	10	8.3 (ac)
Selenium	ND	ND	ND	---	ND	---	71 (ac)
Silver	3.2	ND	ND	ND	ND	---	2.3 (ae)
Thallium	ND	ND	ND	---	ND	---	1.5 (u)
Zinc	34	28	115	77	163	60	86 (ac)

Notes:

Groundwater concentrations are reported on dissolved basis. Residential Stormwater, Puyallup River, and Reichhold Ditch surface water data are reported on a total non-filtered basis.

Data qualifiers and cross references are presented in Table 6.

Table 24 - Mass Flux of Selected Constituents

	Arsenic	Copper	Nickel	Zinc
	flux in pounds/day			
Groundwater Contribution from Blair Backup Property to Backfill around Taylor Way Stormwater Drain (a)	0.58	0.092	0.09	.015
Groundwater Contribution from Blair Backup Property to Reichhold S Ditch (a)	0.39	0.082	0.67	0.73
Taylor Way Stormwater Drain (b)	88	135	81	777
Puyallup River (c)	65,000	1,132,000	260,000	1,245,000

Notes:

- (a) Flux based on average volumetric groundwater flow to backfill and mean concentration of constituent on Blair Backup Property.
- (b) Flux based on midpoint of range of flow (560 gpm) estimated for drain using the Manning equation for full pipe flow and residential stormwater data collected as part of Metro's Toxicants in Urban Runoff Study (December 1982).
- (c) Flux estimated from typical flow in Puyallup River at Puyallup, Washington (3,000 cfs) and samples collected by the U.S. Geological Survey (Ebbert et al., 1987).

Table 25 - Selection of Chemicals of Potential Concern - Blair Backup Property

Page 1 of 2

Chemical	Soils	Groundwater	Surface Water	Sediments
ORGANIC CHEMICALS				
Acetone				
Benzene		X		
Benzoic acid				
Bis(2-ethylhexyl)phthalate	X	X		X
2-Butanone				
2,4-DB				
4,4'-DDD				
4,4'-DDE				
4,4'-DDT				
Dibenzofuran				
cis-1,2-Dichloroethene				
trans-1,2-Dichloroethene				
Di-n-octyl phthalate				
Dinoseb				
Ethylbenzene				
Formaldehyde		X		
Methylene chloride				
2-Methylnaphthalene				
4-Methyl phenol				
Phenol				
Polycyclic aromatic hydrocarbons	X	X		X
Tetrachloroethene				
Toluene	X	X		X
Vinyl chloride		X		
Xylenes		X		

Table 25 - (Continued)

Chemical	Soils	Groundwater	Surface Water	Sediments
INORGANIC CHEMICALS				
Antimony	X	X	X	
Arsenic	X	X	X	X
Beryllium		X		
Cadmium	X	X	X	X
Calcium				
Chloride				
Chromium	X	X	X	X
Copper	X	X	X	X
Fluoride				
Iron				
Lead	X	X	X	X
Magnesium				
Manganese	X	X	X	
Mercury	X	X		X
Molybdenum		X	X	
Nickel	X	X	X	X
Silver				
Sodium				
Sulfate				
Zinc	X	X	X	X

X - Selected as chemical of potential concern for this environmental medium, all other chemicals were detected but for reasons described in the text, are unlikely to be of potential concern.

Table 26 - Selection of Exposure Pathways for Quantitative Exposure Assessment

Page 1 of 2

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Quantitative Evaluation?	Basis for Selection or Exclusion
Current-Use Exposures			
Trespassers	Direct contact with on-site surface soil/incidental ingestion	No	Surface soil contamination in GF, NS, OFA/P Areas. Not completely fenced. Site entry expected to be infrequent. Risks will be compared qualitatively with other potential exposures.
	Inhalation of VOCs volatilized from on-site soil	No	Subsurface soil concentrations of VOCs low compared to groundwater. Entry onto property expected to be infrequent.
	Inhalation of VOCs volatilized from on-site groundwater.	No	VOCs detected in Shallow Aquifer. Site not fenced, but entry onto property expected to be infrequent. Risks will be compared qualitatively with other potential exposures.
	Direct contact with on-site surface water and sediment.	No	Ponding on site is seasonal, does not support fish, so are not attractive to trespassers. Contact with ditches expected to be rare.
Current off-site workers	Inhalation of VOCs volatilized from on-site groundwater, transported in air to workplace.	Yes	VOCs of concern detected in on-site groundwater, nearest industrial building <100 feet from site.
	Inhalation of fugitive dusts generated by wind erosion from surface soils.	Yes	Surface soils contaminated with metals, semivolatile organics.
Current off-site residents	Inhalation of VOCs or fugitive dusts transported in air to residences	No	Nearest residence >3000 feet from site. Exposures would be minor compare to those for workers adjacent to site.
	Ingestion of groundwater from Shallow or Intermediate Aquifers.	No	Groundwater not used for domestic water supply in area.
Future-Use Exposures			
Future on-site industrial workers	Inhalation of VOCs volatilized from soil	No	Releases minor compared to releases from groundwater.
	Inhalation of VOCs volatilized from groundwater	Yes	Volatile organics present in groundwater beneath site.
	Inhalation of fugitive dusts generated from surface soils by wind erosion and vehicles.	Yes	Surface soils contaminated with metals, semivolatile organics.
	Dermal contact with and incidental ingestion of soils.	Yes	Surface soils contaminated with metals, semivolatile organics.
Potential Exposures Associated with Off-Site Transport in Groundwater or Surface Water			
Current off-site workers	Ingestion or inhalation of chemicals in off-site groundwater	No	Shallow or intermediate zone groundwater is not used for water supply.
	Direct contact and incidental ingestion of surface water (in ditches)	No	Concentrations in surface water lower than sediments, so would not contribute substantially to risk.

Table 26 - (Continued)

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Quantitative Evaluation?	Basis for Selection or Exclusion
Current off-site residents	Direct contact and incidental ingestion of sediment.	Yes	Off-site workers may occasionally contact ditch sediment.
	Ingestion of groundwater.	No	Groundwater does not flow toward residential areas.
	Direct contact with surface water runoff from site (ditches)	No	Surface water does not flow into residential areas.
	Consumption of vegetables or livestock raised with off-site groundwater	No	No agricultural use of area groundwater.
	Dermal contact and inhalation exposure to chemicals discharged from groundwater into waterways.	No	Shorelines near site are highly industrialized. Recreational use is highly unlikely.
	Ingestion of fish or shellfish from Hylebos and Blair waterways.	Yes	Commercial fishing occurs in Commencement Bay.

Table 27 - Summary of Potential Health Risks at the Blair Backup Property

	Potential Upper-bound Excess Lifetime Cancer Risks		Hazard Index	
	Average	RME	Average	RME
CURRENT-USE SCENARIOS				
Inhalation by off-site workers of chemicals volatilizing from on-site groundwater				
-- North Site	3×10^{-9}	2×10^{-8}	--	--
-- OFA/Pennwalt	2×10^{-9}	9×10^{-9}	<1	<1
-- Total	5×10^{-9}	3×10^{-8}	<1	<1
Inhalation by off-site workers of fugitive dust emitted from on-site soils				
-- North Site	2×10^{-9}	9×10^{-9}	<1	<1
-- OFA/Pennwalt	1×10^{-7}	7×10^{-7}	<1	<1
-- General/Fill	5×10^{-9}	2×10^{-8}	<1	<1
-- Total	1×10^{-7}	7×10^{-7}	<1	<1
FUTURE-USE SCENARIOS				
Inhalation by on-site workers of chemicals volatilizing from on-site groundwater:				
-- North Site	1×10^{-5}	2×10^{-5}	--	--
-- OFA/Pennwalt	7×10^{-7}	1×10^{-6}	<1	<1
Inhalation by on-site workers of fugitive dust emitted from on-site soils:				
-- North Site	4×10^{-7}	2×10^{-6}	<1	<1
-- General/Fill	3×10^{-7}	1×10^{-6}	<1	<1
-- OFA/Pennwalt				
-- w/charcoal	5×10^{-6}	3×10^{-5}	>1 (2)	>1 (5)
-- w/o charcoal	5×10^{-6}	2×10^{-5}	>1 (2)	>1 (5)
Direct contact with soils by on-site workers				
-- North Site	7×10^{-7}	6×10^{-6}	<1	<1
-- General/Fill	1×10^{-7}	2×10^{-6}	<1	<1
-- OFA/Pennwalt				
-- w/charcoal	3×10^{-5}	6×10^{-4}	<1	>1 (4)
-- w/o charcoal	3×10^{-6}	3×10^{-5}	<1	<1

Table 27 - Continued

Sheet 2 of 2

	Potential Upper-bound Excess Lifetime Cancer Risks		Hazard Index	
	Average	RME	Average	RME
Direct contact with sediments by on-site workers				
- Pennwalt Ag-Chem Ditch	2×10^{-7}	2×10^{-6}	<1	<1
- Ohio Ferro Alloy Ditch	1×10^{-6}	1×10^{-5}	<1	<1
OFF-SITE GROUNDWATER MIGRATION SCENARIOS				
Ingestion of Fish from Blair Waterway	1×10^{-9}	1×10^{-7}	<1	<1
Ingestion of Fish from Hylebos Waterway	7×10^{-10}	8×10^{-8}	<1	<1

227-4.14

Table 28 - Summary of Potential Multipathway Risks

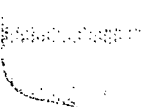
	Potential Upper-bound Excess Lifetime Cancer Risks		Hazard Index	
	Average	RME	Average	RME
CURRENT-USE SCENARIOS				
Multipathway risks for current off-site workers: inhalation of volatiles and particulates.	1×10^{-7}	7×10^{-7}	<1	<1
FUTURE-USE SCENARIOS				
Multipathway risks for future on-site workers: inhalation of volatiles and particulates; direct contact with soils and sediments.				
-- North Site	1×10^{-5}	3×10^{-5}	<1	<1
-- General/Fill	4×10^{-7}	3×10^{-6}	<1	<1
-- OFA/Pennwalt				
--with charcoal	3×10^{-5}	6×10^{-4}	>1(2)	>1(5)
--without charcoal	9×10^{-6}	5×10^{-5}	>1(2)	>1(5)
OFF-SITE GROUNDWATER MIGRATION SCENARIOS				
Multipathway risks to off-site residents from ingestion of fish from Blair or Hylebos waterways	1×10^{-9}	1×10^{-7}	<1	<1

TML2-7.1a

1



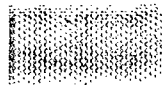
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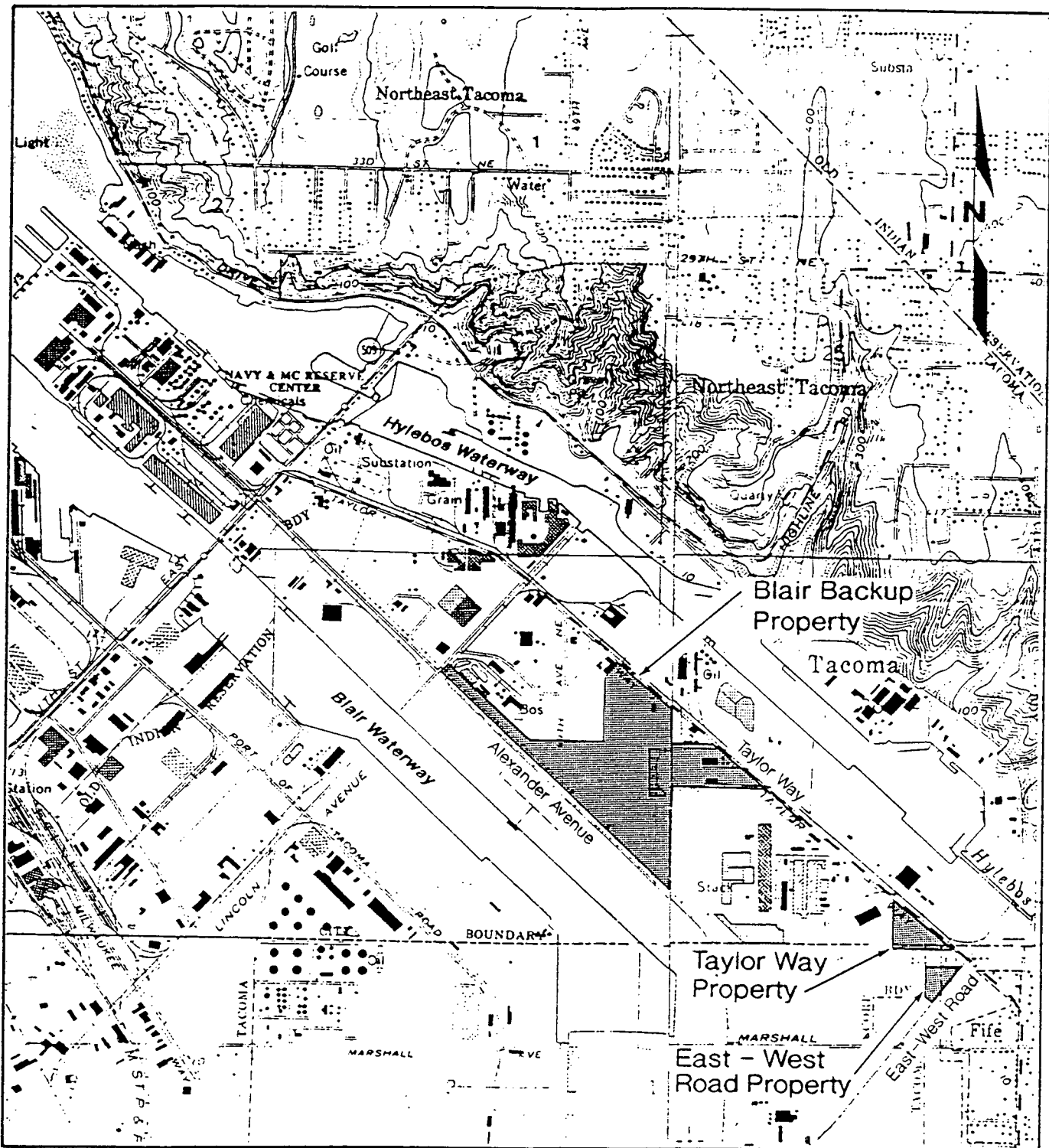
Plate



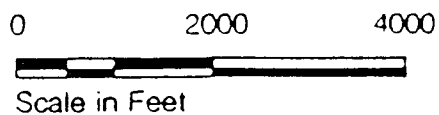
Figures



Vicinity Map

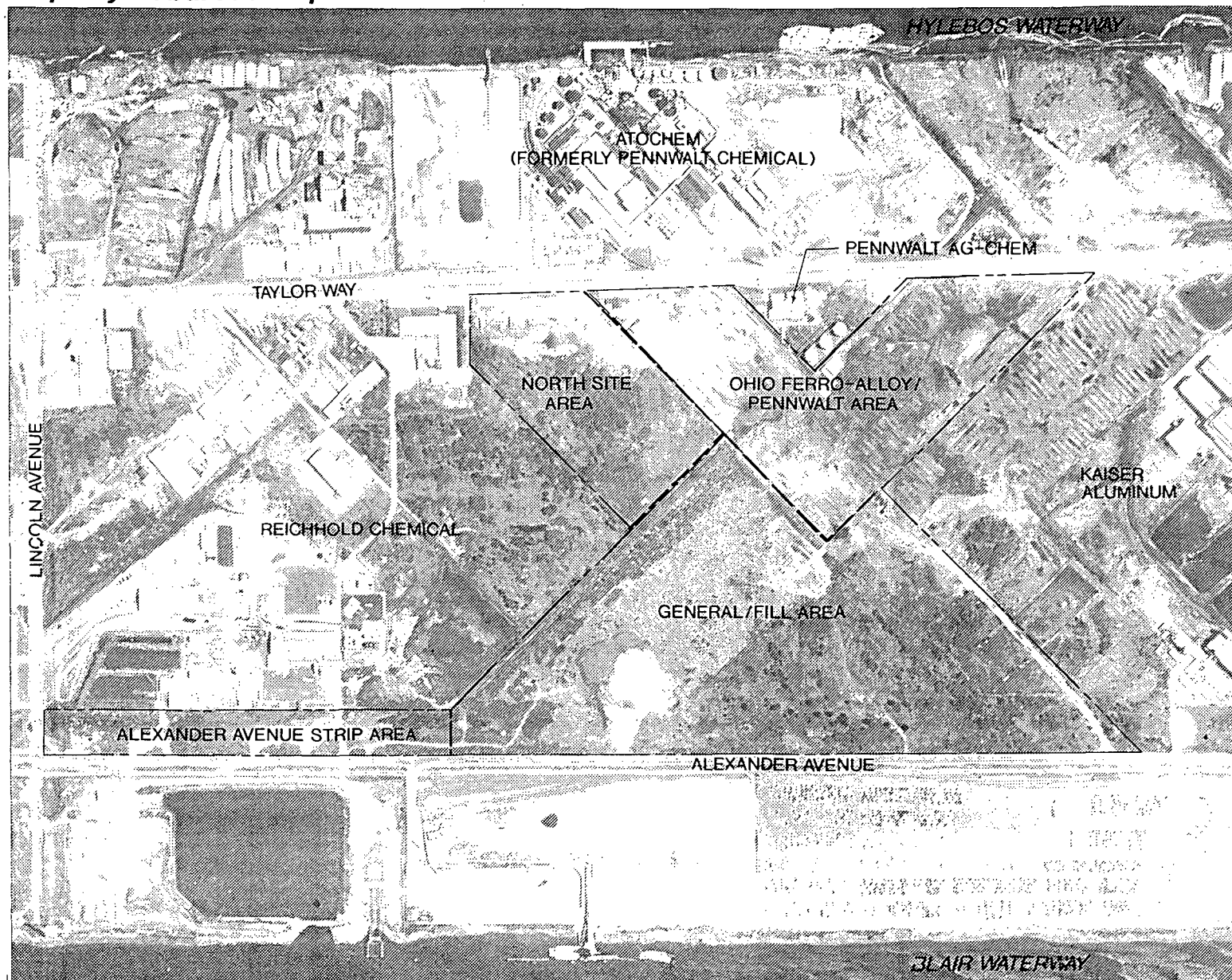


Base map prepared from USGS 7.5-minute quadrangles, Tacoma North and Proverly Bay, Washington, photorevised 1981.

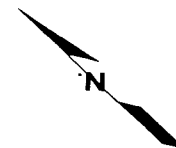


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J-2350-07 5/91
Figure 1

Property Subareas Map

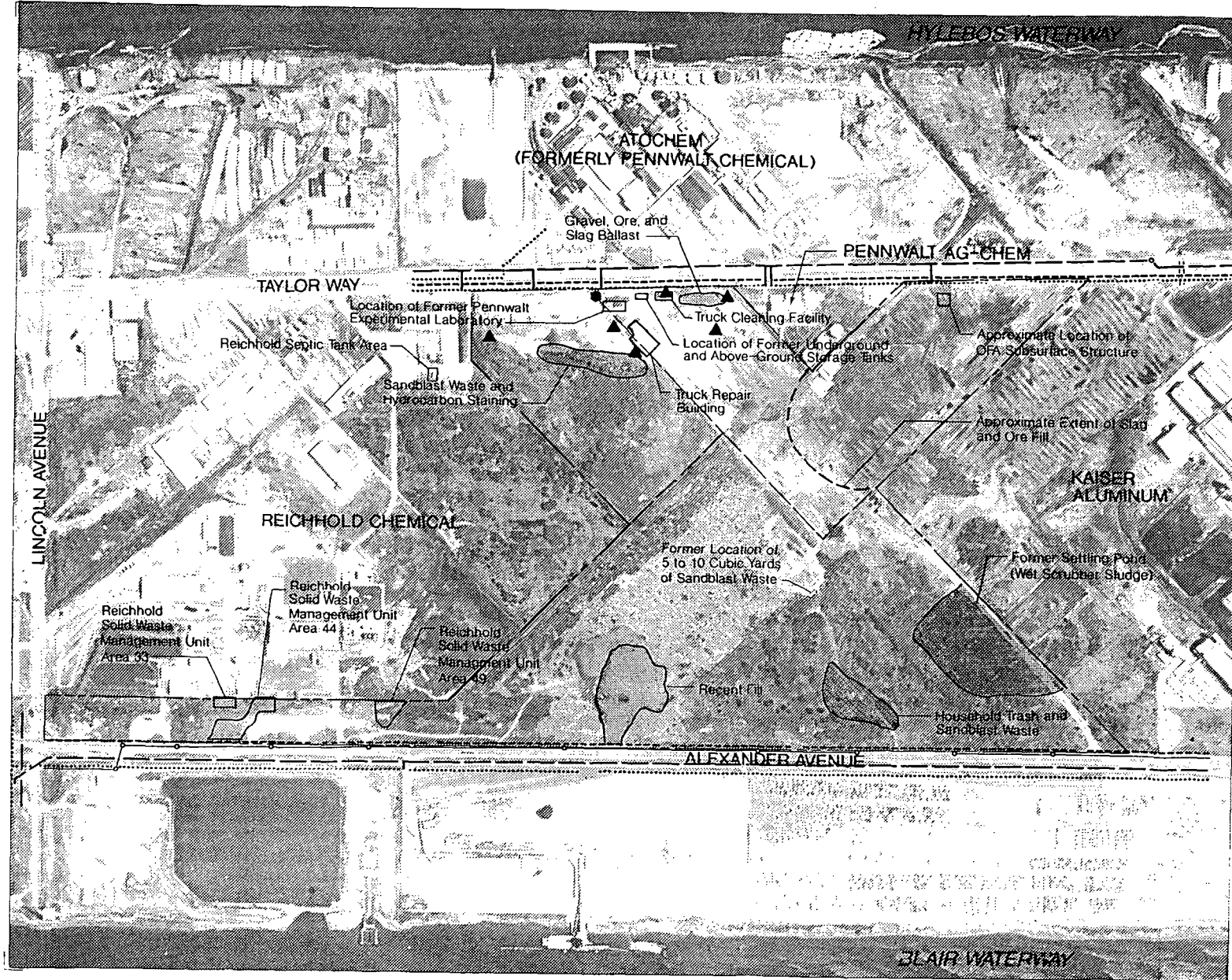


Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet

Pertinent Features Map



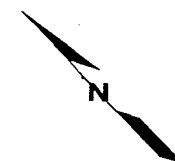
Utility Line Location

- Water Main
- Storm (Manhole)
- HP Gas
- Sanitary

Note. Sanitary sewer pipe from Reichhold fence to Pennwalt fence along Taylor Way is buried approximately 11 to 9 feet below ground surface.

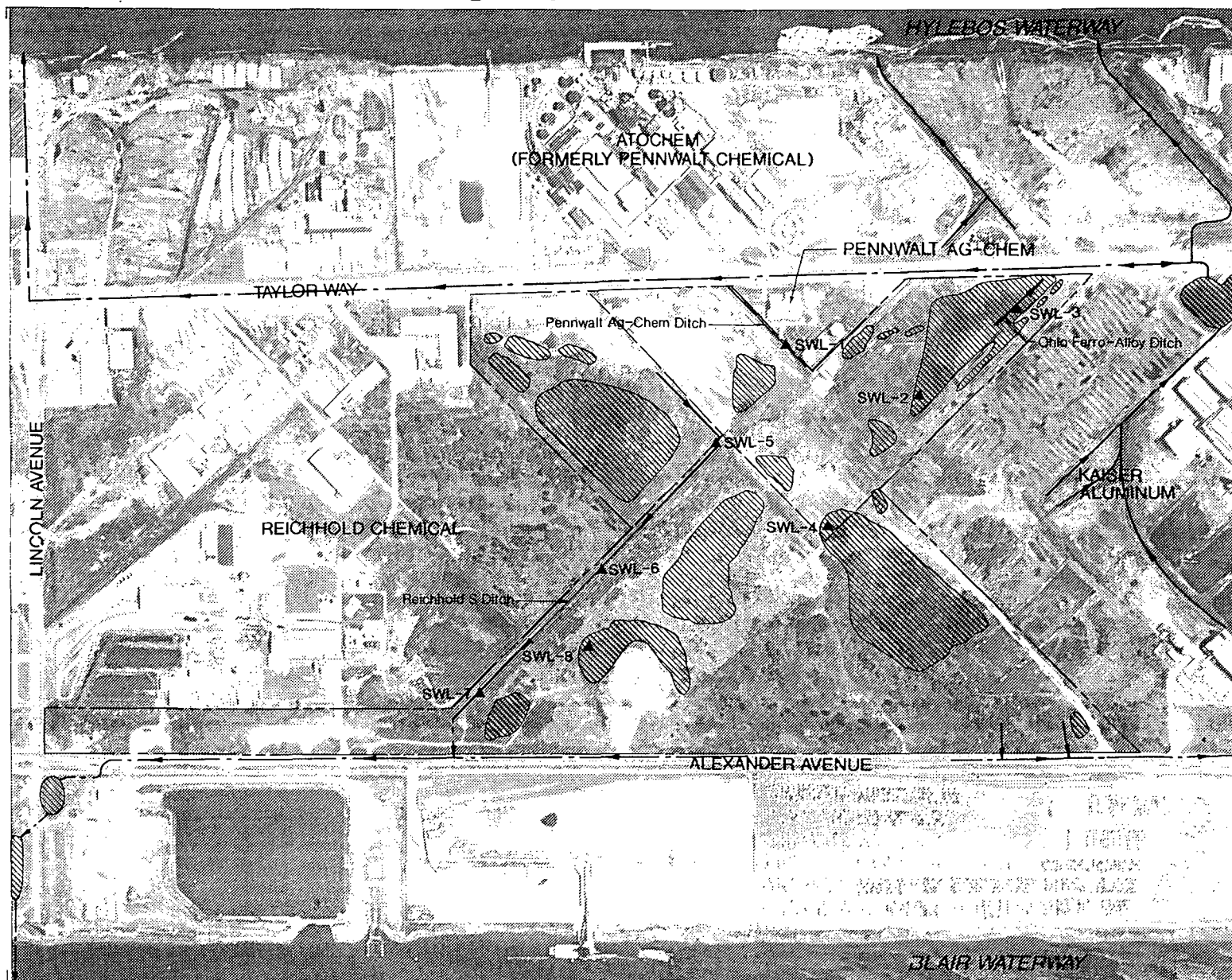
- ▲ — Drums of 55 Gallon or Smaller Containing Oil Waste Materials
- — Asbestos Piping


Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1969.



0 400 800
Approximate Scale in Feet

Surface Water Feature and Drainage Map



 Approximate Boundary of Poned Area. Information based on January 1991 observations. Many of these are intermittent.

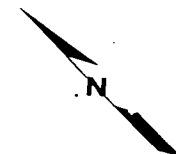
▲ SWL-1 Surface Water Level Gage Location and Number. (Several gages were temporary for Feb. 1990 monitoring.)

--- Closed Surface Water Drainage

— Open Surface Water Drainage

Drainage data obtained from the Commencement Bay-Nearshore/Tidelands Area Drainage Map (TPCHD 1988) with modifications made based on January 1991 observations.

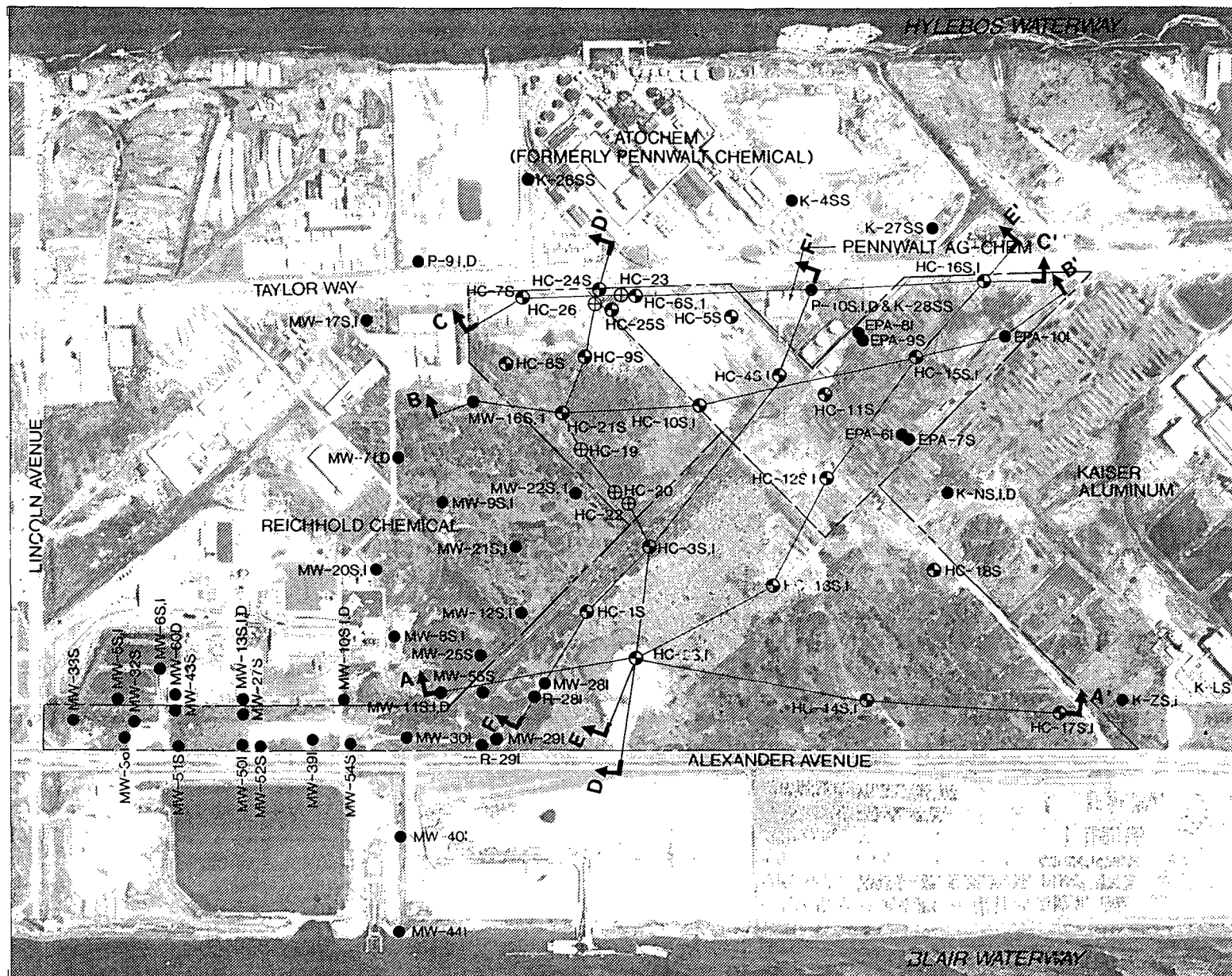
Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet


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Figure 4

Monitoring Well and Boring Location Plan



Monitoring Well Location and Number

- ⊕ HC-1 Hart Crowser
- EPA-9 EPA
- MW-16 CH2M Hill
- P-10 Pennwalt
- K-N Kaiser
- K-27 Kennedy Jenks

Aquifer Tapped by Well

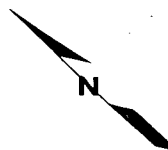
- S Shallow
- I Intermediate
- D Deep

Note: Wells are clustered installations.

- ⊕ HC-26 Hart Crowser Boring

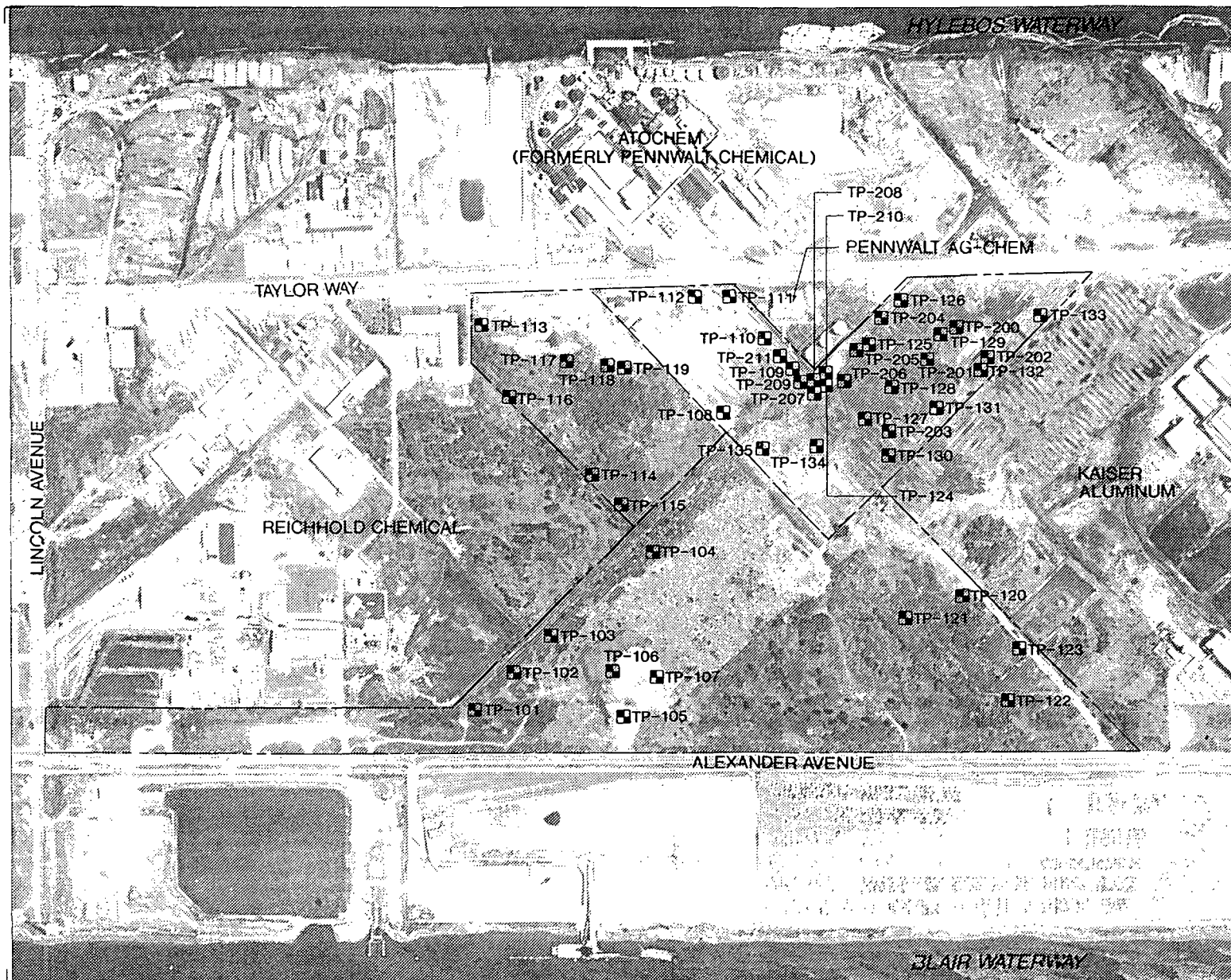
A A' Generalized Hydrogeologic Cross Section Location and Designation

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



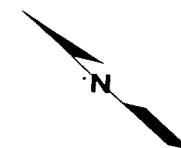
0 400 800
Approximate Scale in Feet

Test Pit Location Plan



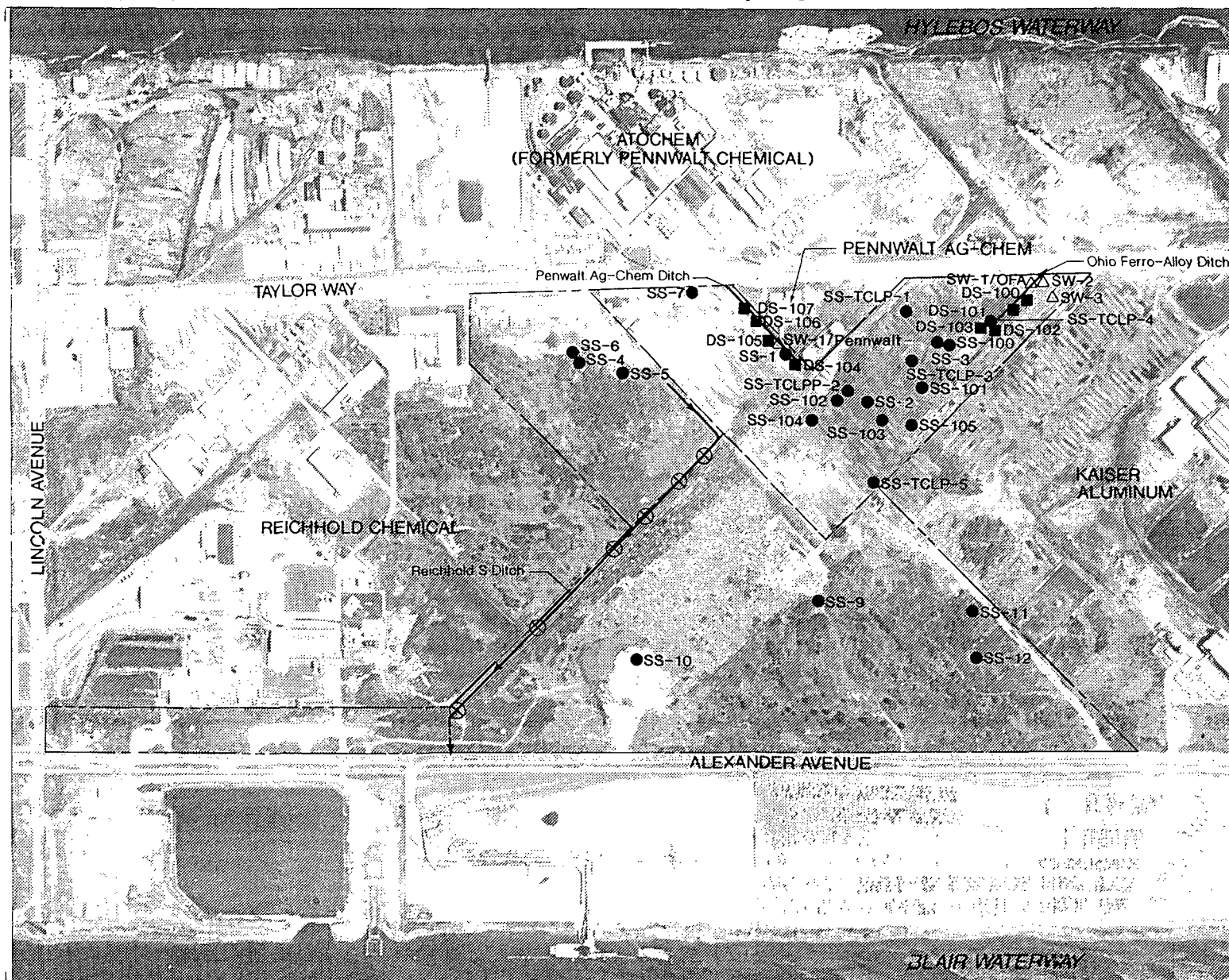
TP-101 Test Pit Location and Number

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1999



0 400 800
Approximate Scale in Feet

Surface Soil, Ditch Sediment, and Surface Water Sampling Location Plan

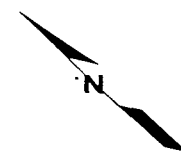


- SS-1 Surface Soil Sampling Location and Number
- DS-100 Ditch Sediment Sampling Location and Number
- △ SW-1 Surface Water Sampling Location and Number

- Surface water sample SW-2 was sampled a second time in January 1991 and was labeled SW-1.

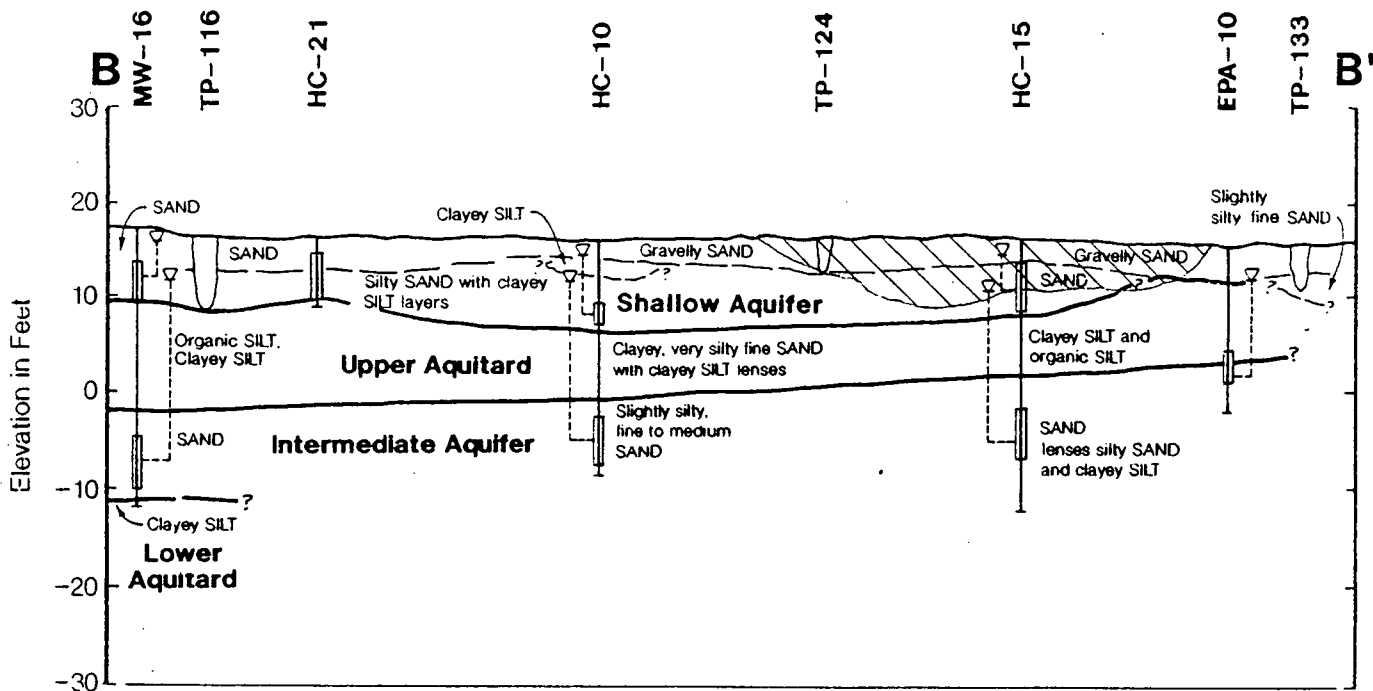
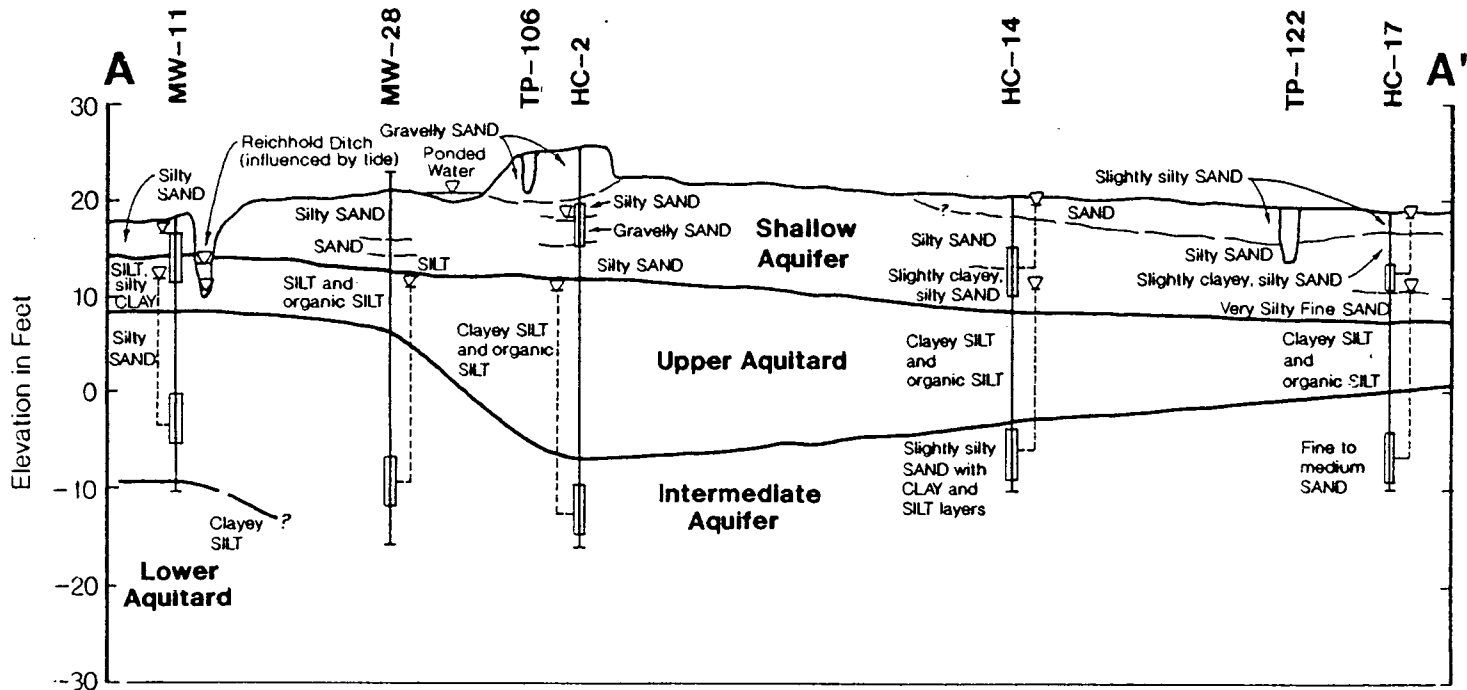
- ⊗ Surface Water and Ditch Sediment Sampling Location by Reichhold (CH2M Hill, 1989c)

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet

Generalized Hydrogeologic Cross Sections A-A' and B-B'



Note: Contacts between soil units are based upon interpolation between explorations and represent our interpretation of subsurface conditions based on currently available data.

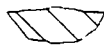
HC-14 Monitoring Well Number (Hart Crowser)

MW-11 Monitoring Well Number (Chizmi Hill)

Monitoring Well Location
Water Level (2/2/90)
Screened Section

TP-133 Test Pit Number

Test Pit Location



FILL/Slag Material

See Figure 5 for Cross Section Locations

Horizontal Scale in Feet

0 400 800
0 20 40

Vertical Scale in Feet

Vertical Exaggeration x 20



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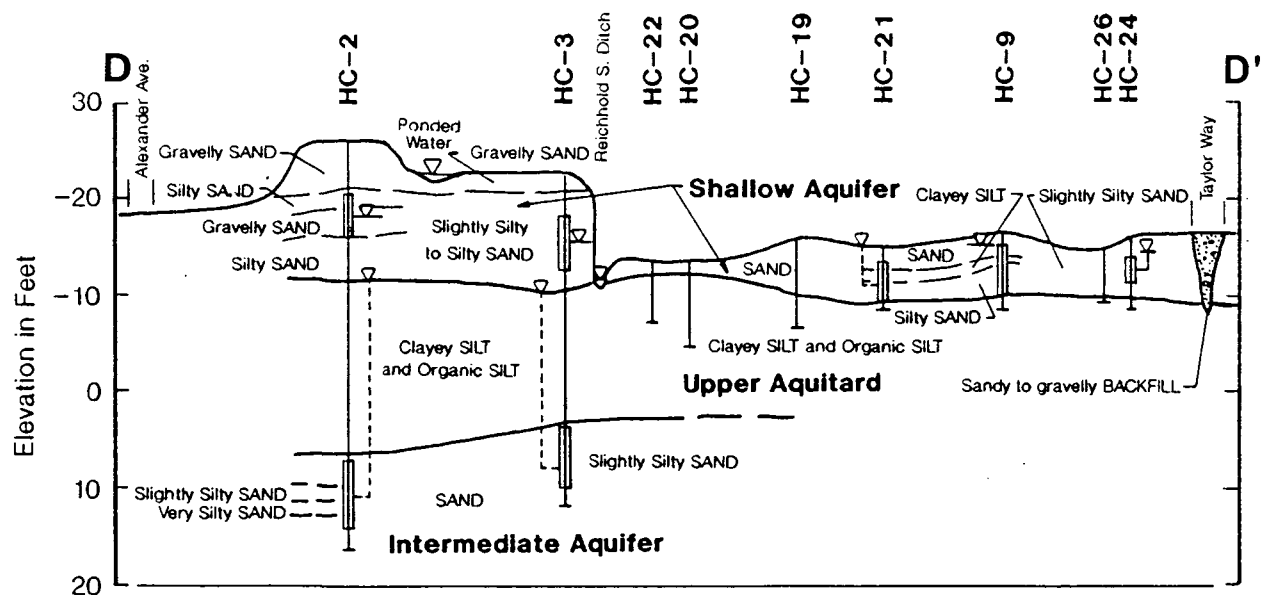
J-2350-07 5/91

Figure 8

This geological cross-section diagram illustrates the subsurface geology along the Pennwall Ditch. The vertical axis represents Elevation in Feet, ranging from -30 to 30. The horizontal axis shows the locations of various monitoring points: TP-113, HC-7, HC-6, TP-112, TP-111, P-10, TP-126, and HC-16. The diagram identifies several geological layers and features:

- Shallow Aquifer:** Located near the surface, containing layers of Gravelly SAND, Silty SAND, and Clayey SILT. It is separated from the underlying layers by an Upper Aquitard.
- Upper Aquitard:** A layer of Silty SAND and Sandy SILT that acts as a barrier to groundwater flow between the Shallow and Intermediate Aquifers.
- Intermediate Aquifer:** A layer of Silty SAND and Silty CLAY that provides a secondary source of groundwater.
- Lower Aquitard:** A layer of Clayey SILT and Slightly silty SAND that acts as a barrier between the Intermediate and Lower Aquifers.
- Other Features:** The Pennwall Ditch is shown as a surface feature. Other layers include GRAVEL and Slag, Silty, gravelly SAND, and Sandy SILT to silty SAND with Peat.

The diagram shows the varying thickness and composition of these layers across the different monitoring points, providing a detailed view of the local hydrogeology.



Horizontal Scale in Feet
0 400 800
0 20 40
Vertical Scale in Feet
Vertical Exaggeration $\times 20$

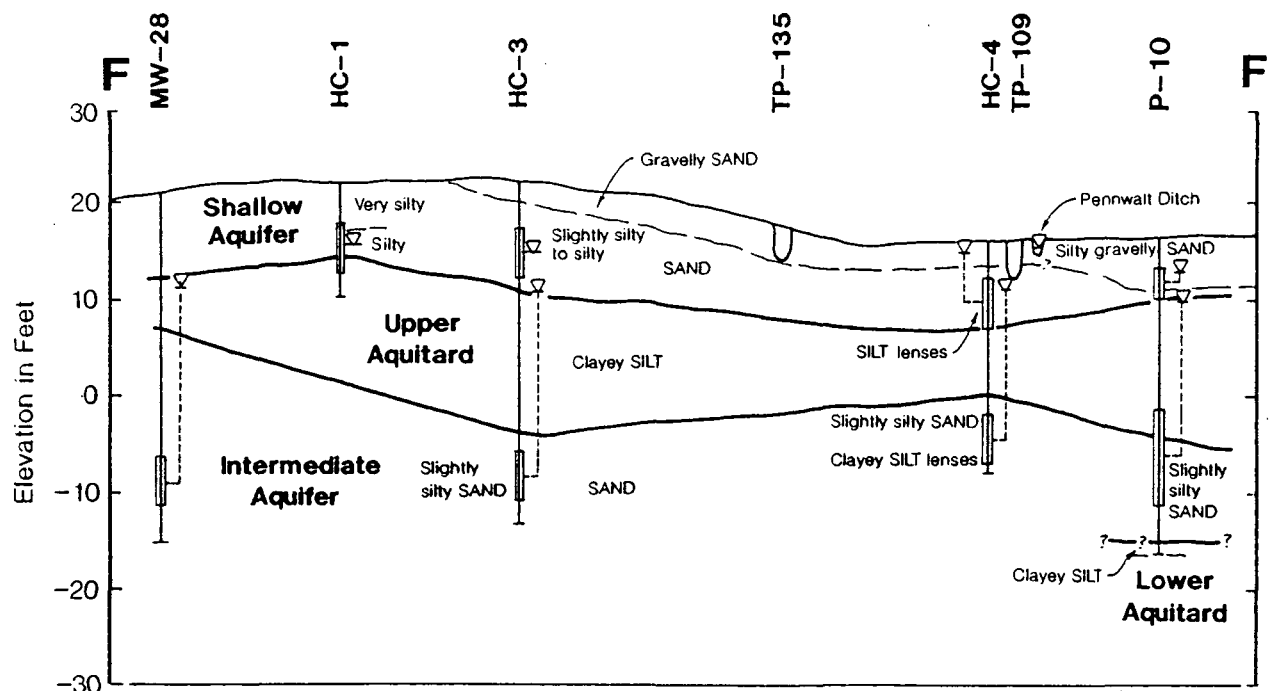
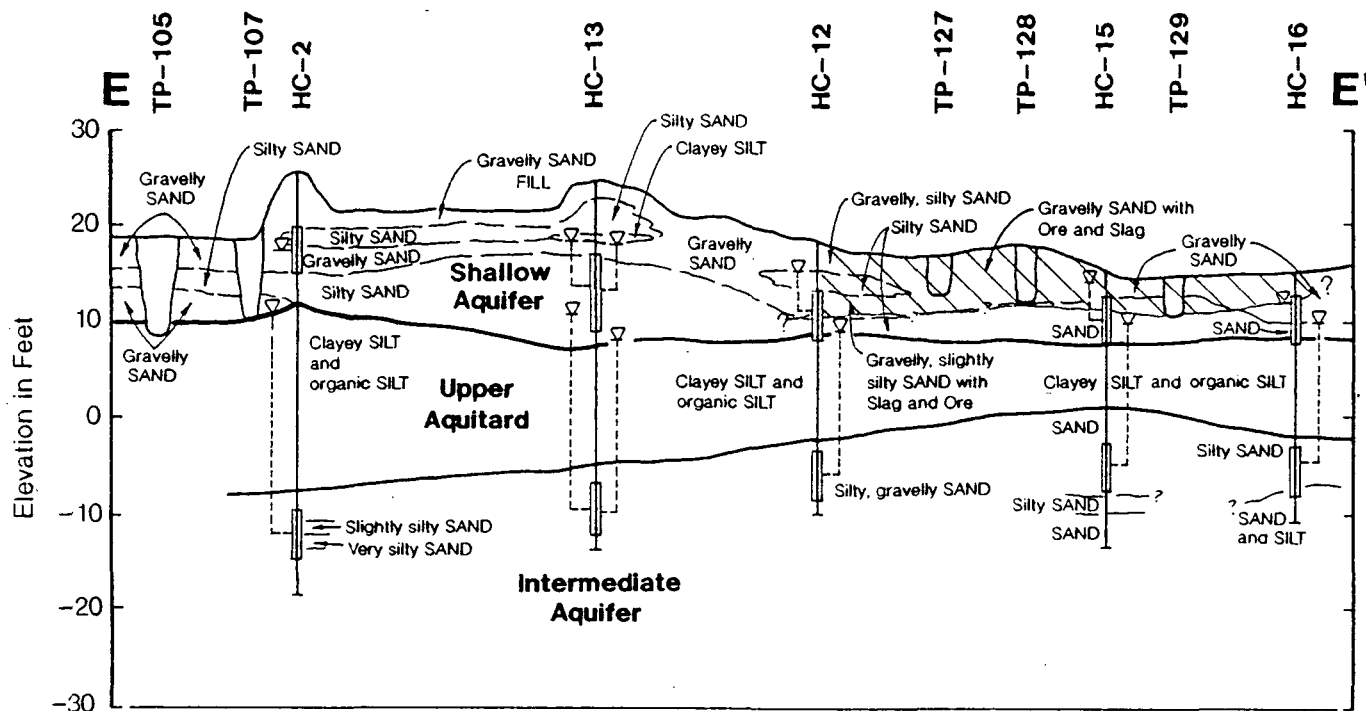
Screened Section



See Figure 5 for Cross Section Locations

Figure 9

Generalized Hydrogeologic Cross Sections E-E' and F-F'



Note: Contacts between soil units are based upon interpolation between explorations and represent our interpretation of subsurface conditions based on currently available data.

Horizontal Scale in Feet
0 400 800
Vertical Scale in Feet
0 20 40
Vertical Exaggeration x 20

HC-12 Monitoring Well Number (Hart Crowser)

MW-28 Monitoring Well Number (CH₂M Hill)

Monitoring Well Location

Water Level (2/2 '90)

Screened Section

TP-105 Test Pit Number

Test Pit Location

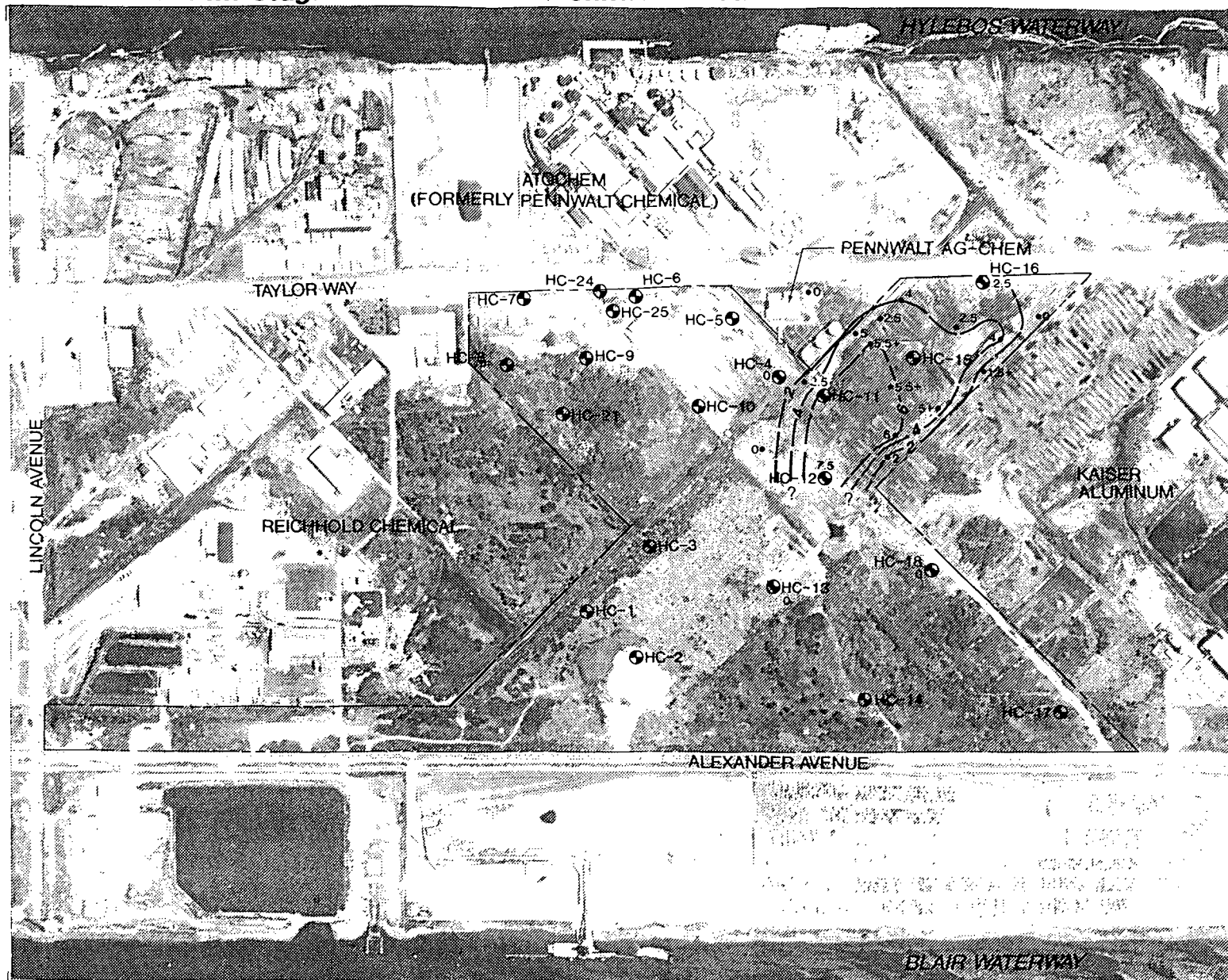


FILL/Slag Material

See Figure 5 for Cross Section Locations

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J-2350-07 5/91
Figure 10

Thickness of Fill/Slag Material in OFA/Pennwalt Area



HC-1

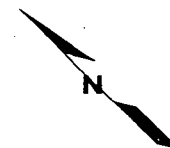
•4

Thickness of Fill/Slag Material
in Feet in Exploration

4

Fill/Slag Thickness Contour
in Feet
Contour Interval=2 Feet

Note: Base map prepared from aerial photograph of
the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet

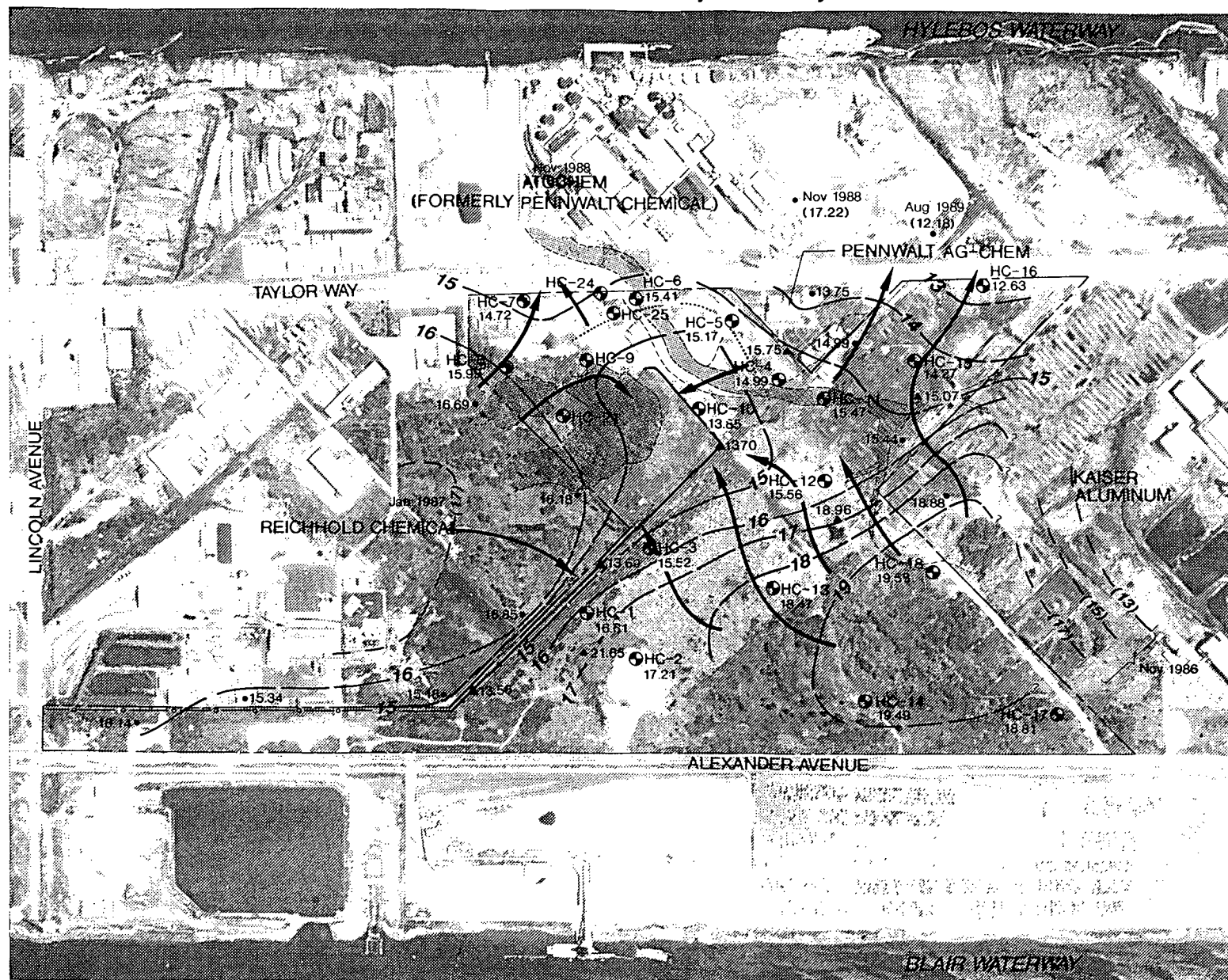


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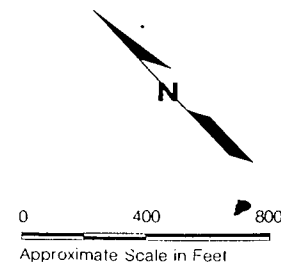
Figure 11

Shallow Aquifer Groundwater Elevation Contour Map February 1990

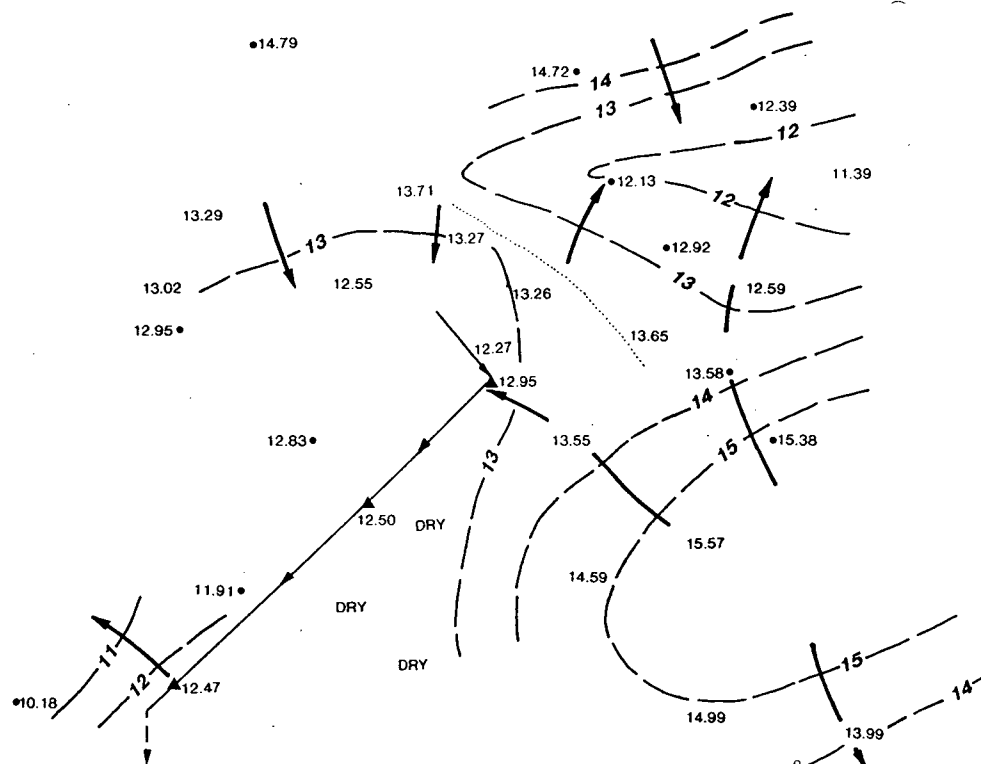


- HC-1 Hart Crowser Monitoring Well Location and Number
- 14.27 Groundwater Elevation in Feet – POT Datum (Data for February 2, 1990 High Tide 8:00 a.m. – 10:00 a.m.)
- (16.39) Spot Groundwater Elevation in Feet – Pennwalt (Data for Time Indicated)
- 14 — Groundwater Elevation Contour in Feet
- - (17) - - Groundwater Elevation Contour in Feet Adjacent Property (Data for Time Indicated)
- ← Groundwater Flow Direction
- ▲ 13.56 Surface Water Level Elevation in Feet
- ○ ○ ○ Approximate Location of Reichhold Shallow Aquifer Interceptor Trench
- ○ ○ ○ Approximate Location of Original Tidelat Drainage Network
- Approximate Groundwater Divide

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.

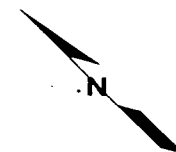


Shallow Aquifer Groundwater Elevation Contour Map September 1990



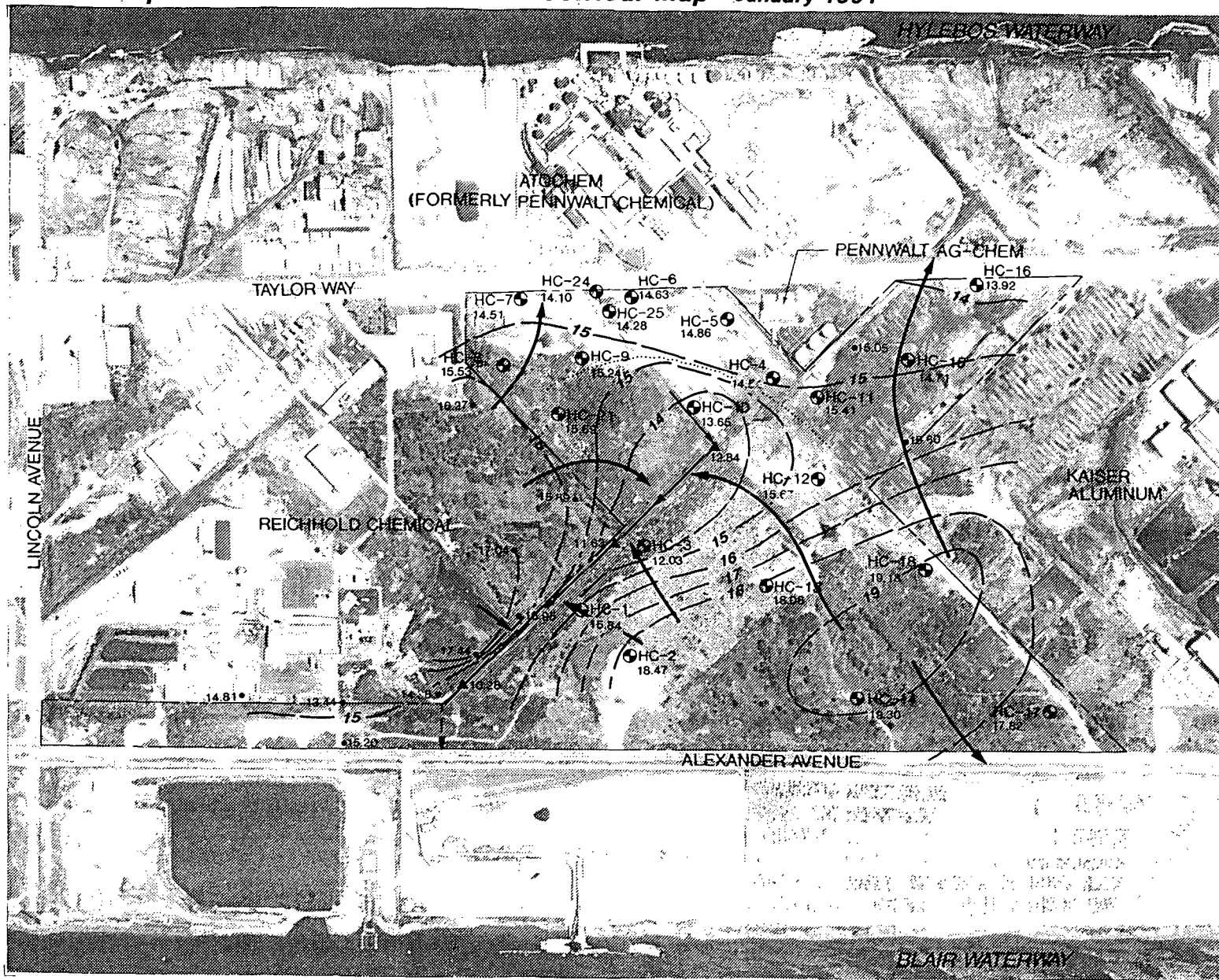
- Hart Crowser Monitoring Well Location and Number
- 11.39 Groundwater Elevation in Feet - POT Datum (Data for September 11, 1990 High Tide 11:00 a.m. - 1:00 p.m.).
 - ▲12.95 Surface Water Level Elevation in Feet
 - 14- Groundwater Elevation Contour in Feet
 - Groundwater Flow Direction
 - Approximate Groundwater Divide

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



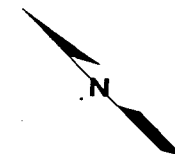
0 400 800
Approximate Scale in Feet

Shallow Aquifer Groundwater Elevation Contour Map January 1991






- HC-1 Hart Crowser Monitoring Well Location and Number
- 15.41 Groundwater Elevation in Feet - POT Datum (Data for January 25, 1991 High Tide 10:00 a.m. - 12:00 p.m.)
- ▲ 11.63 Surface Water Elevation in Feet
- 14 - Groundwater Elevation Contour in Feet
- Groundwater Flow Direction
- - - - - Approximate Groundwater Divide

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



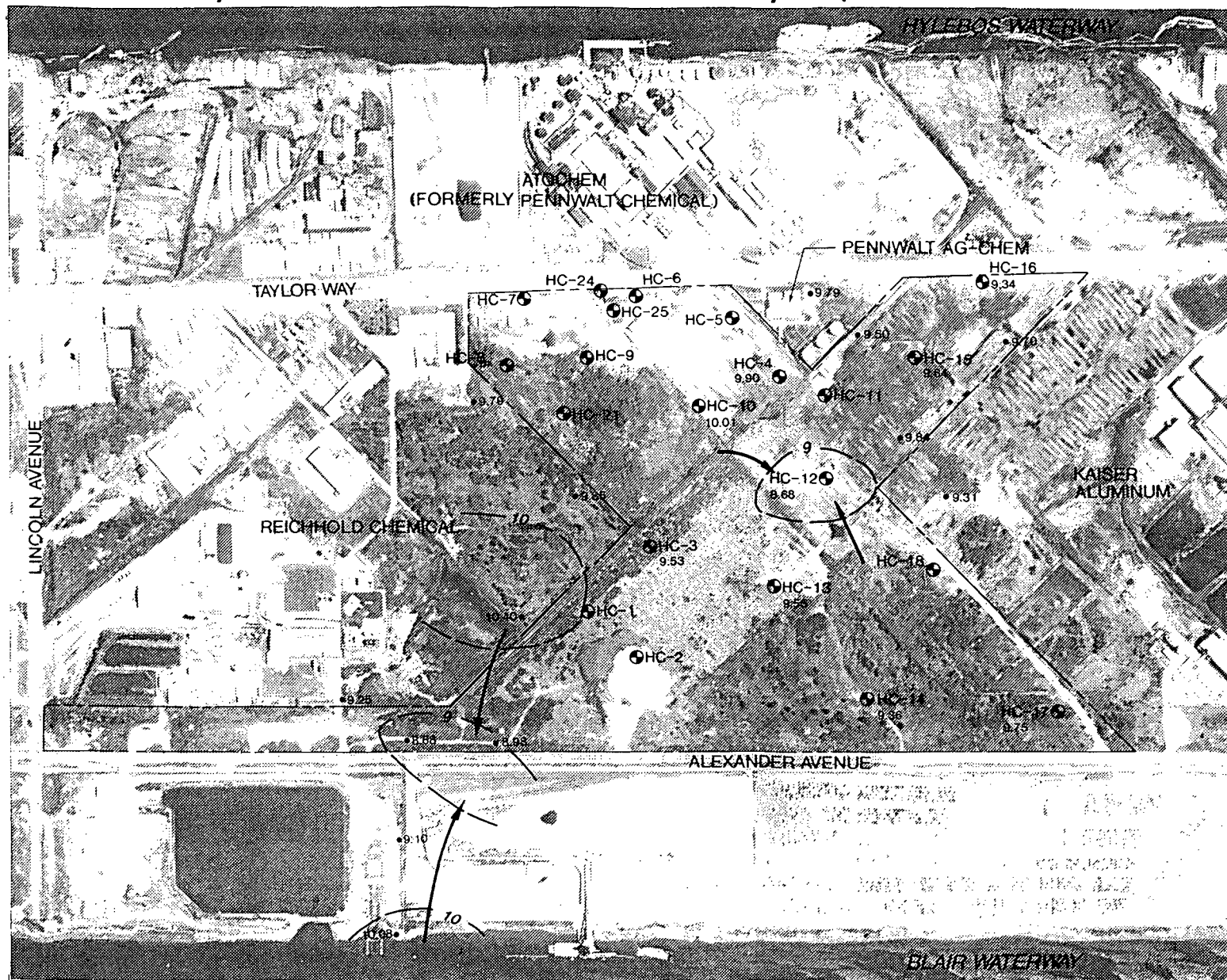
0 400 800
Approximate Scale in Feet

[illegible]

 **11** — Groundwater Elevation Contour in Feet
 **(7)** — Groundwater Elevation Contour in Feet
 Adjacent Property
 (Data for Time Indicated)
 — Groundwater Flow Direction


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 Figure 15

Intermediate Aquifer Groundwater Elevation Contour Map September 1990



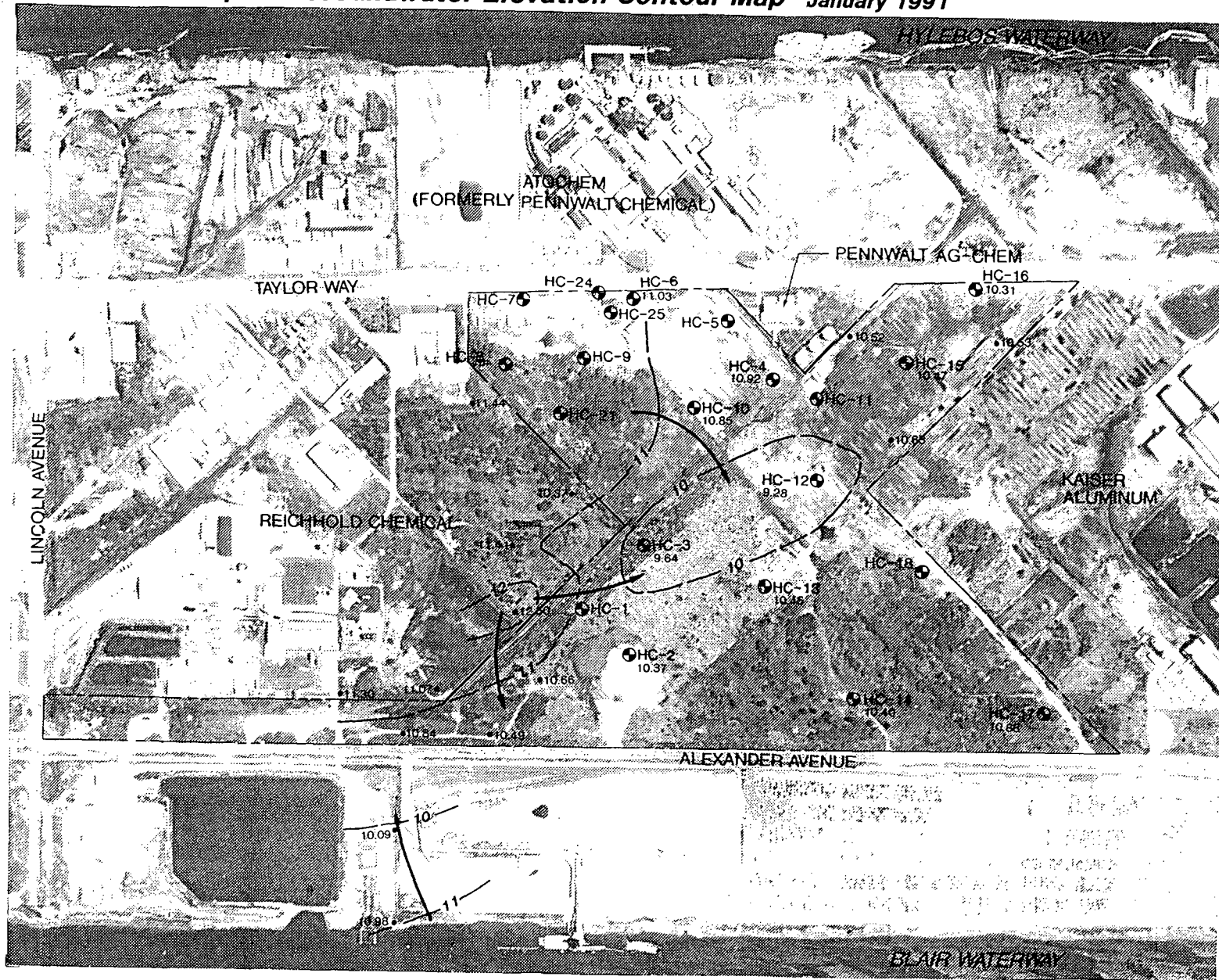
- HC-1 Hart Crowser Monitoring Well Location and Number
- 9.90 Groundwater Elevation in Feet-POT Datum (Data for September 11, 1990 High Tide 11:00 a.m.-1:00 p.m.)
- 9 - Groundwater Elevation Contour in Feet
- Groundwater Flow Direction

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



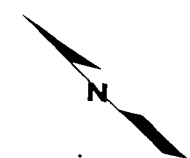
0 400 800
Approximate Scale in Feet

Intermediate Aquifer Groundwater Elevation Contour Map January 1991



- HC-1 Hart Crowser Monitoring Well Location and Number
- 11.03 Groundwater Elevation in Feet-POT Datum (Data for January 25, 1991 High Tide 10:00 a.m.-12:00 p.m.)
- 10- Groundwater Elevation Contour in Feet
- Groundwater Flow Direction

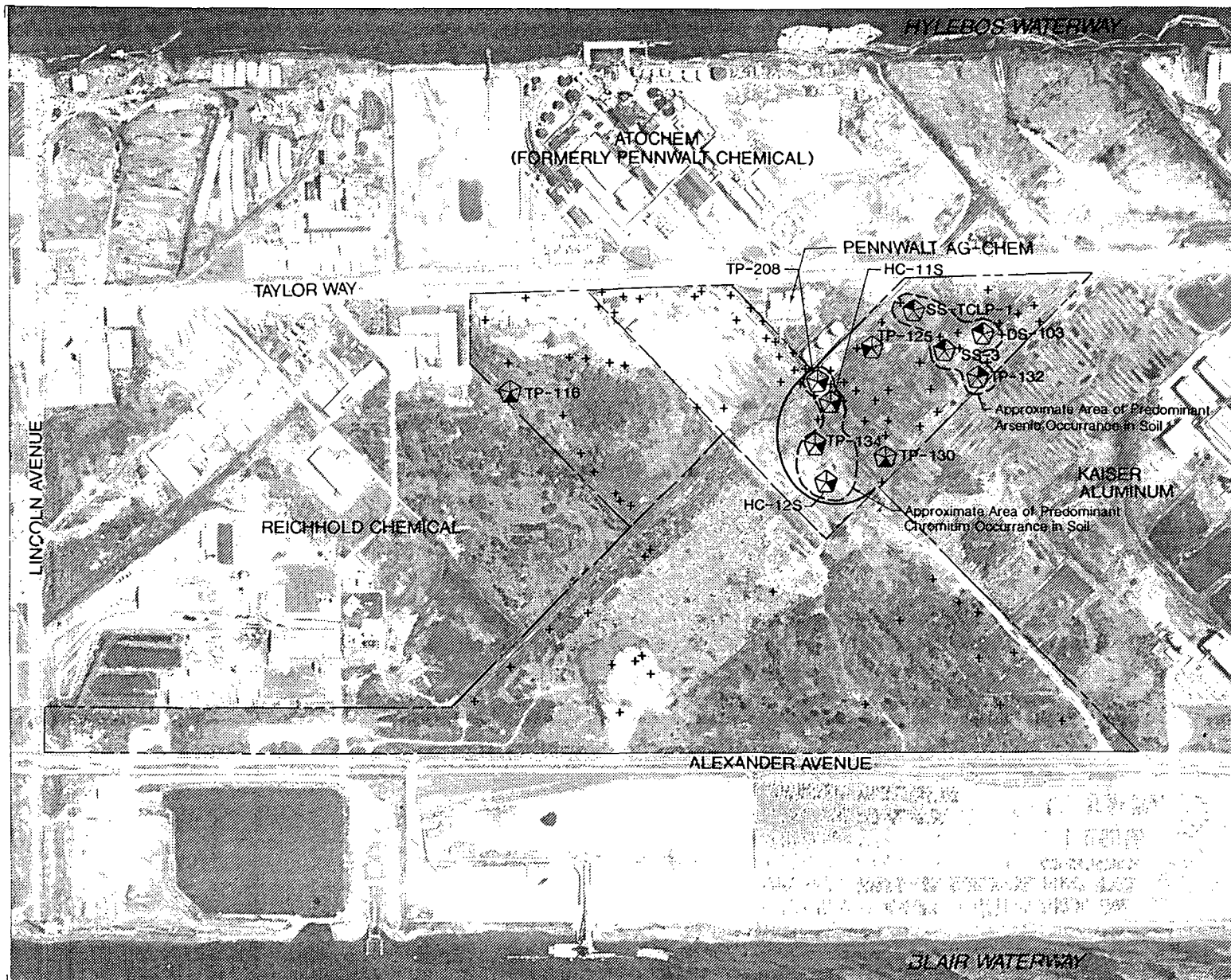
Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet

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Figure 17

Location of Soil Samples Exceeding MTCA Cleanup Levels **Total Metals**



Arsenic
Cadmium
Lead
Chromium
Mercury

- Darkened sections indicate exceedence of MTCA Method A industrial cleanup levels for the corresponding trace metal.

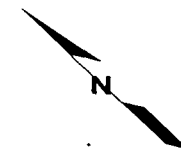
+ Location in which metal concentrations do not exceed MTCA Method A industrial cleanup levels

— Approximate extent of Fill/Slag material in OFA/Pennwalt Area

MTCA Method A Industrial Soil Cleanup levels in mg/kg

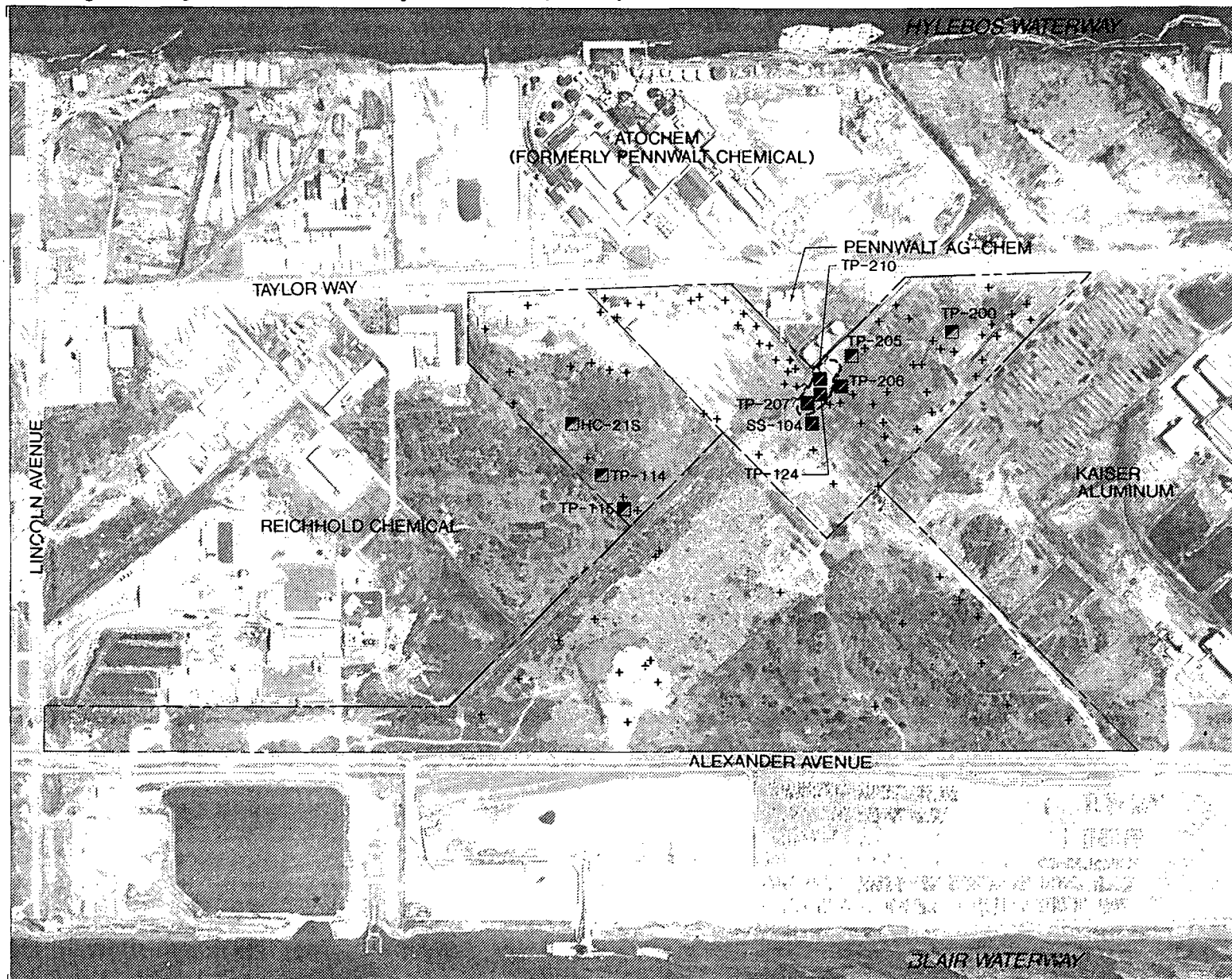
Arsenic	200
Cadmium	10
Chromium	500
Lead	1000
Mercury	1

Notes: 1) Exceedences of MTCA soil cleanup levels are presented for reference purposes only. Exceedence of these criteria do not necessarily indicate the need for remedial actions.
 2) Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
 Approximate Scale in Feet

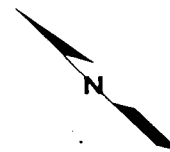
Location of Soil Samples Exceeding MTCA Cleanup Levels Carcinogenic Polynuclear Aromatic Hydrocarbons (cPAHs)



- Total cPAH concentration not adjusted for toxicity effect factors (TEFs) exceeding the MTCA Method C industrial cleanup level of 10 mg/kg
- ▣ Total cPAH concentration adjusted using TEFs exceeding the MTCA Method C industrial cleanup level
- +
- Location in which cPAHs were not detected or were present below the MTCA Method C industrial cleanup level
- Approximate extent of charcoal in subsurface soils

Notes: 1) Exceedences of MTCA soil cleanup levels are presented for reference purposes only. Exceedence of these criteria do not necessarily indicate the need for remedial actions.

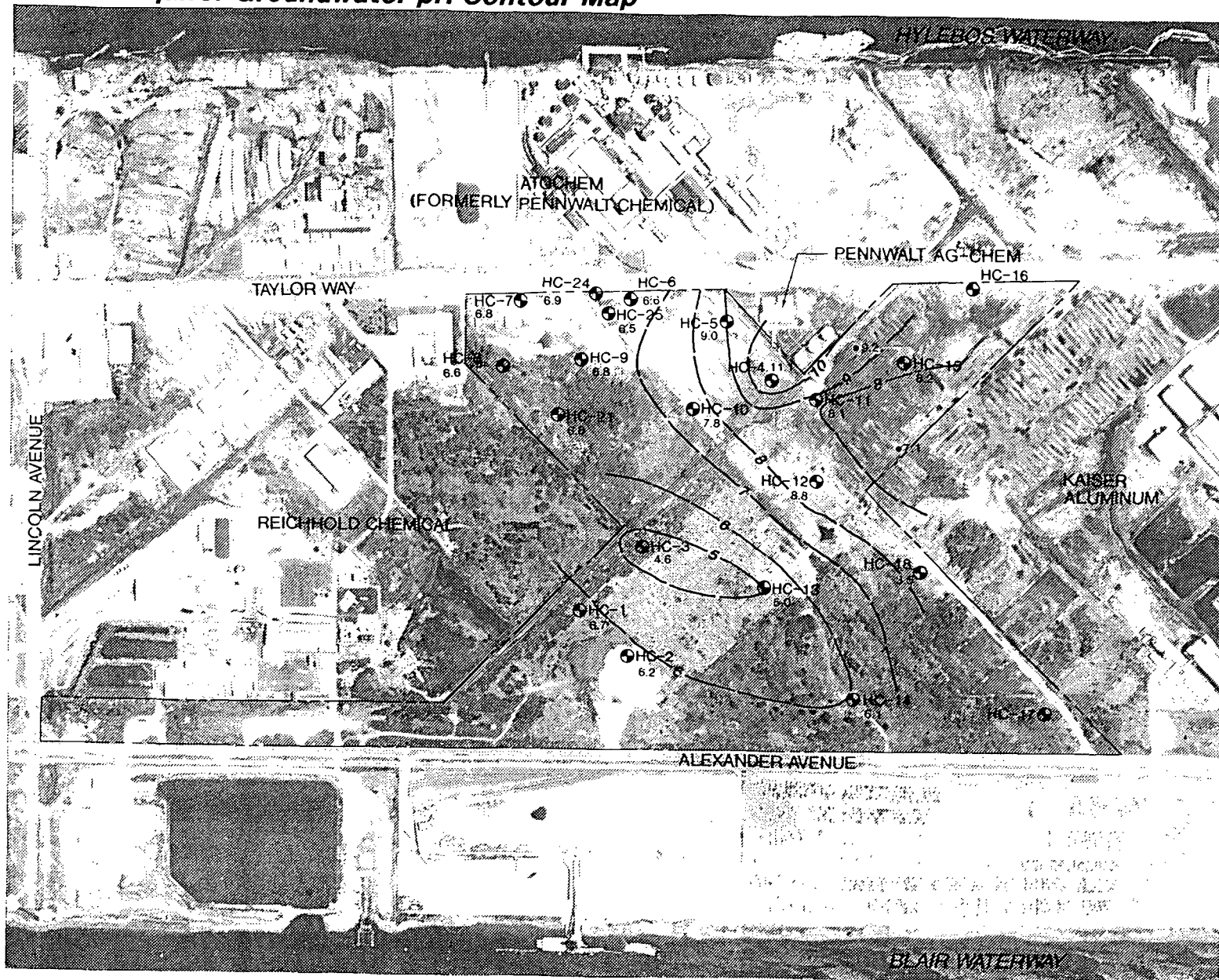
2) Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1969



0 400 800
Approximate Scale in Feet

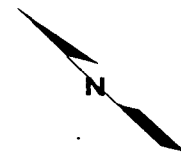
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J-2350-07 5/91
Figure 19

Shallow Aquifer Groundwater pH Contour Map



- HC-1 Hart Crowser Monitoring Well Location and Number
- 5.0 pH Measurement of December 1990 Sampling Round
- 8 — Groundwater pH Contour Contour Interval=1

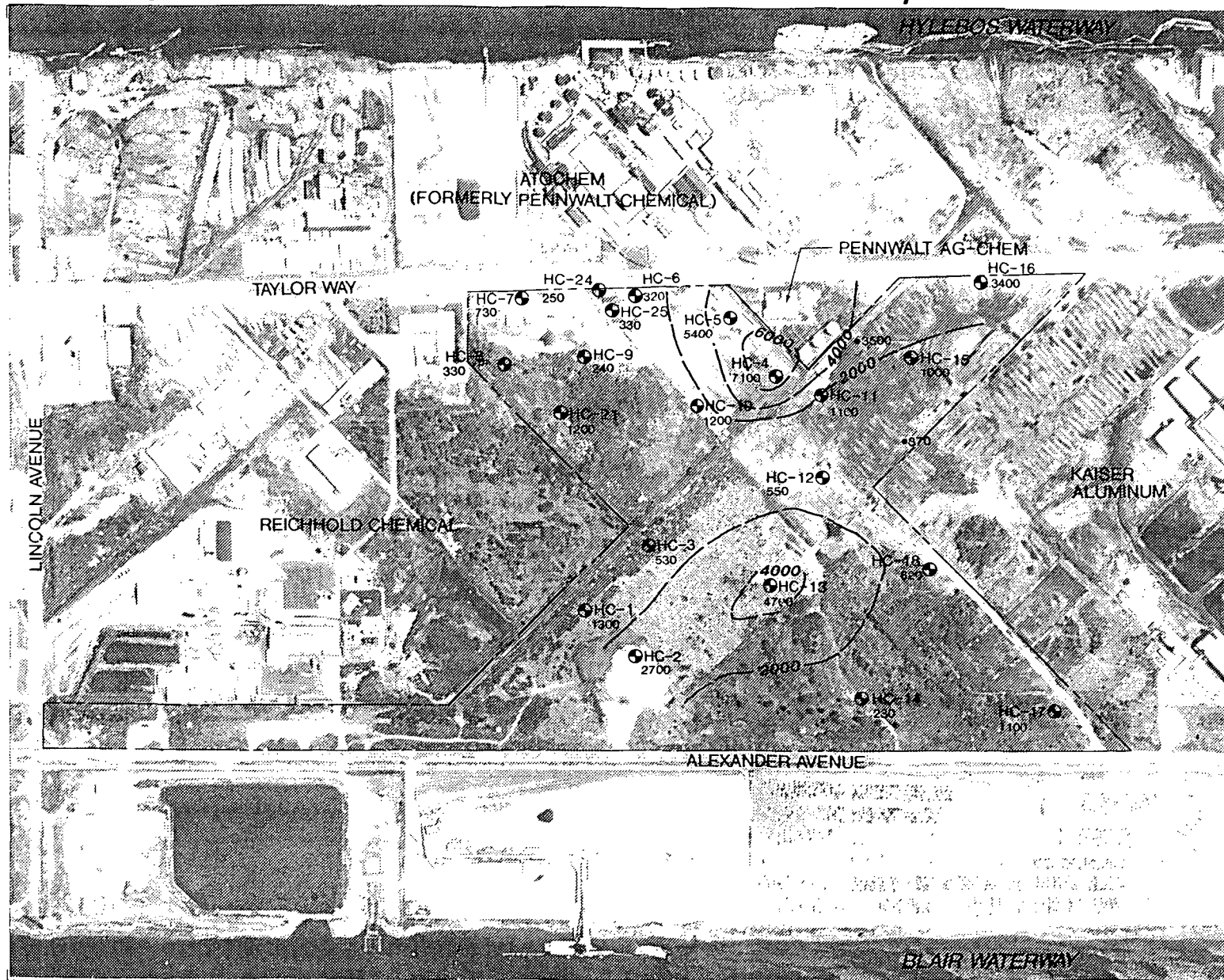
Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet

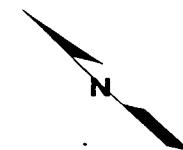
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Figure 20

Shallow Aquifer Total Dissolved Solids Concentration Contour Map



- HC-1 Hart Crowser Monitoring Well Location and Number
- 3500 TDS Concentration in ppm. December 1990 Measurements.
- ~2000~ TDS Concentration Contour in ppm
- Contour Interval=2000 ppm

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.

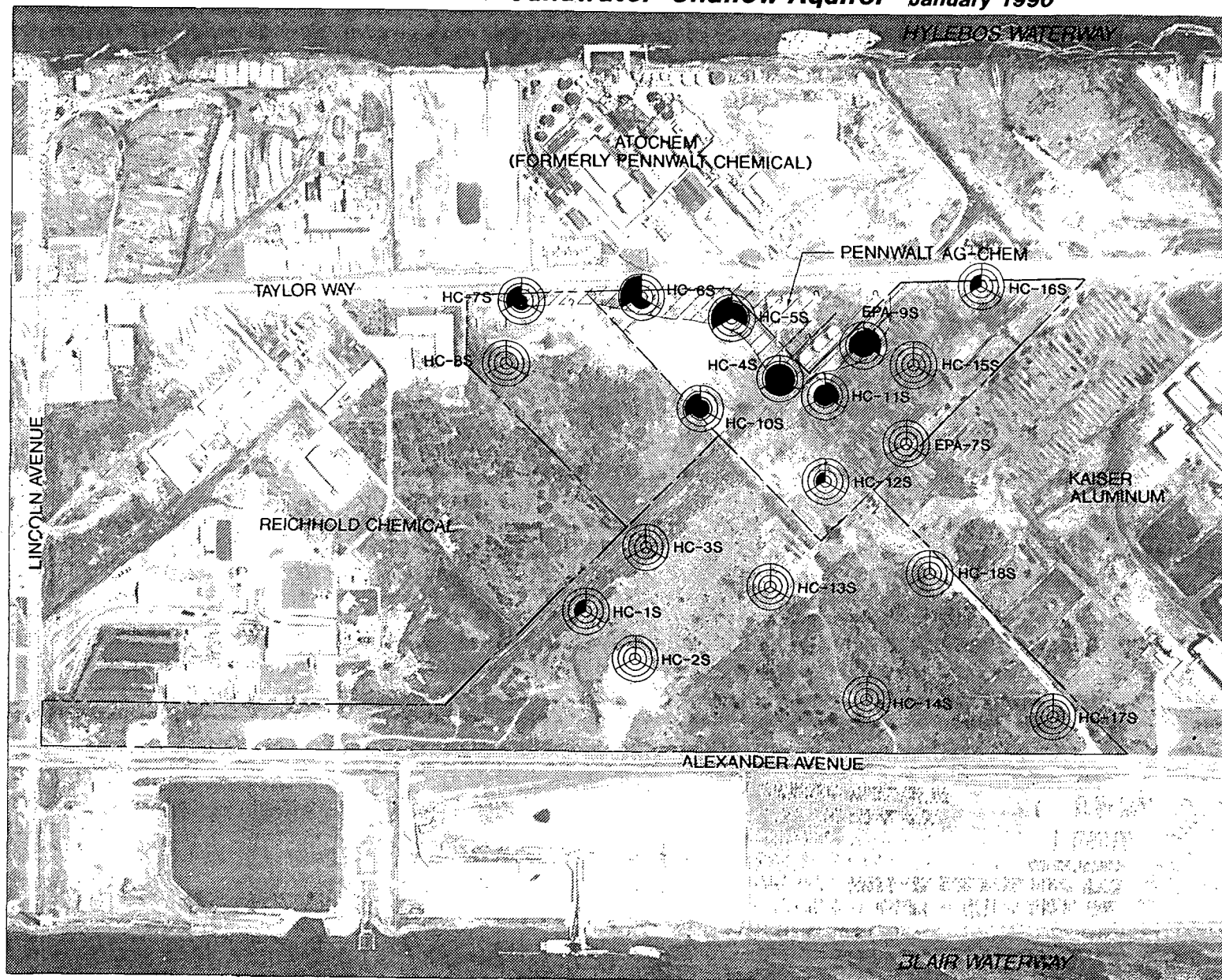


0 400 800
Approximate Scale in Feet

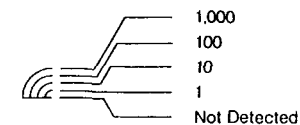


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Figure 21

Selected Metal Concentrations in Groundwater-Shallow Aquifer January 1990



Concentration in $\mu\text{g/L}$ (ppb)



1. Arsenic
2. Chromium
3. Lead

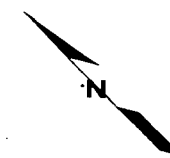


Port of Tacoma Local Groundwater Reference Concentration (Based on Upper 95% Confidence Limit of Mean)



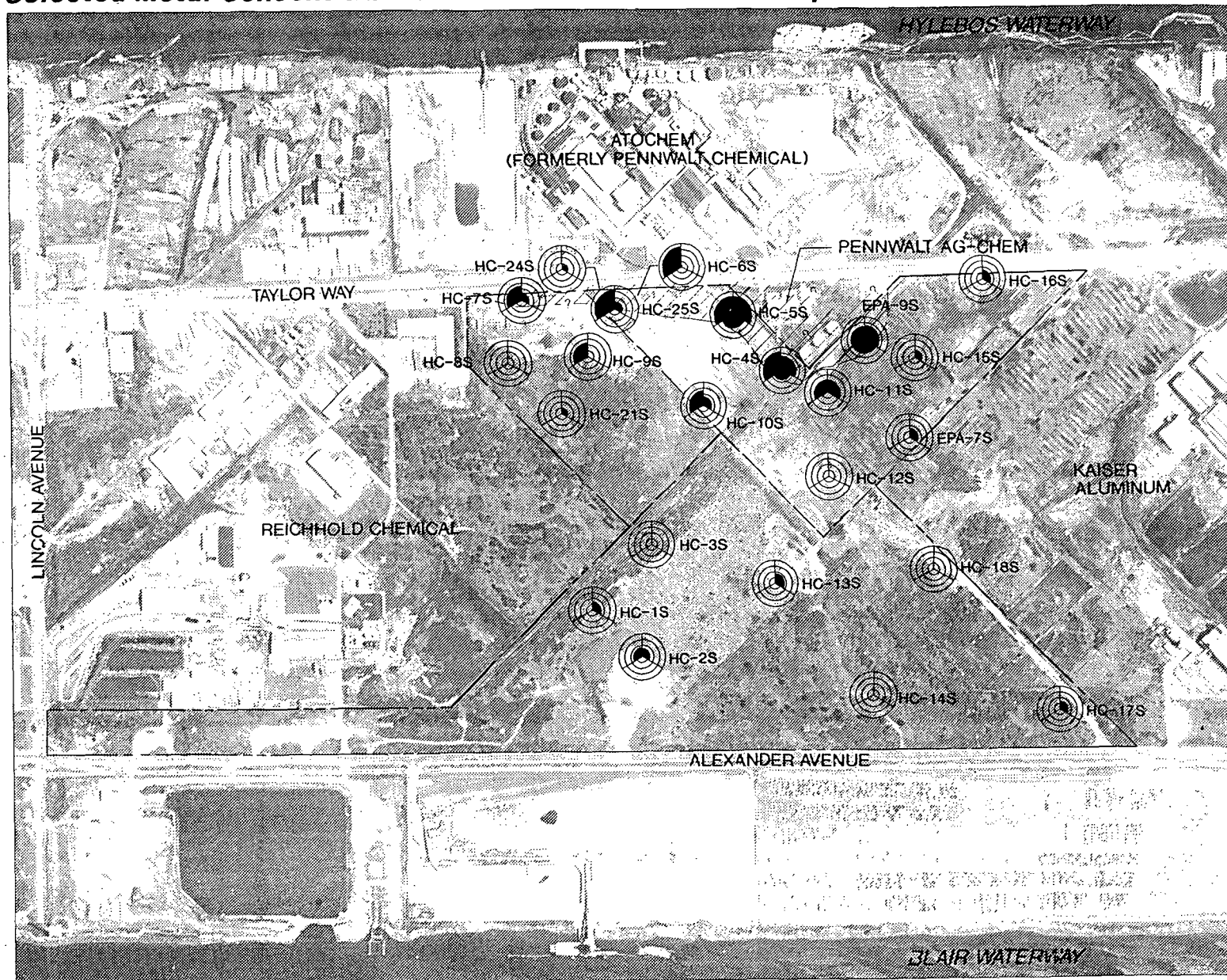
Approximate Area where Arsenic Exceeds the MTCA Method B Cleanup (2ppb) Level and the Marine Chronic Standard (40ppb)

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.

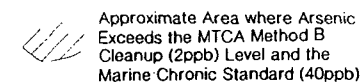
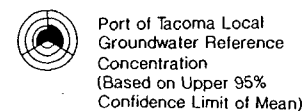
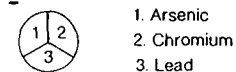
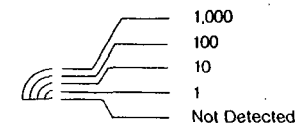


0 400 800
Approximate Scale in Feet

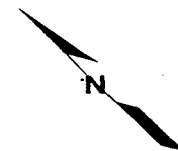
Selected Metal Concentrations in Groundwater-Shallow Aquifer December 1990



Concentration in $\mu\text{g/L}$ (ppb)

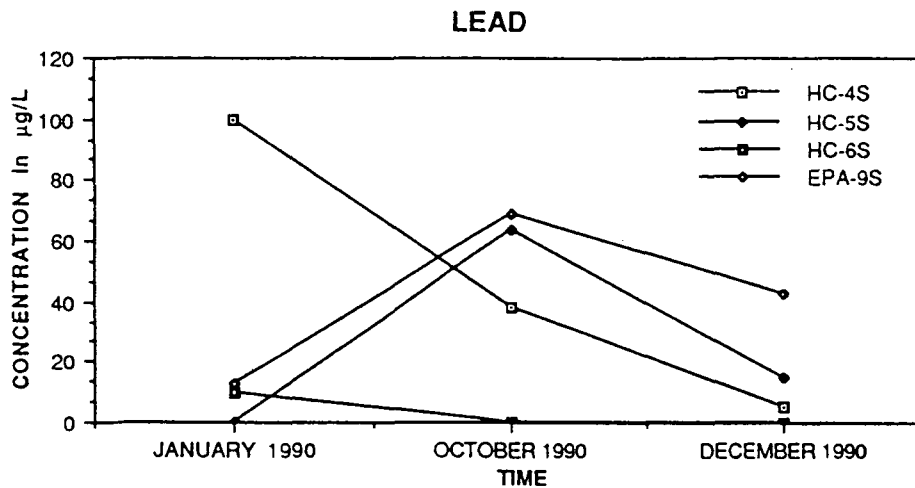
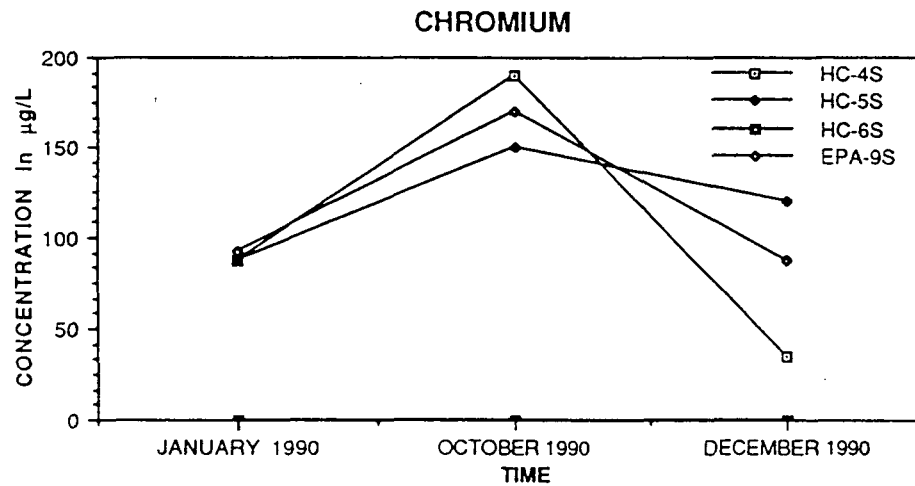
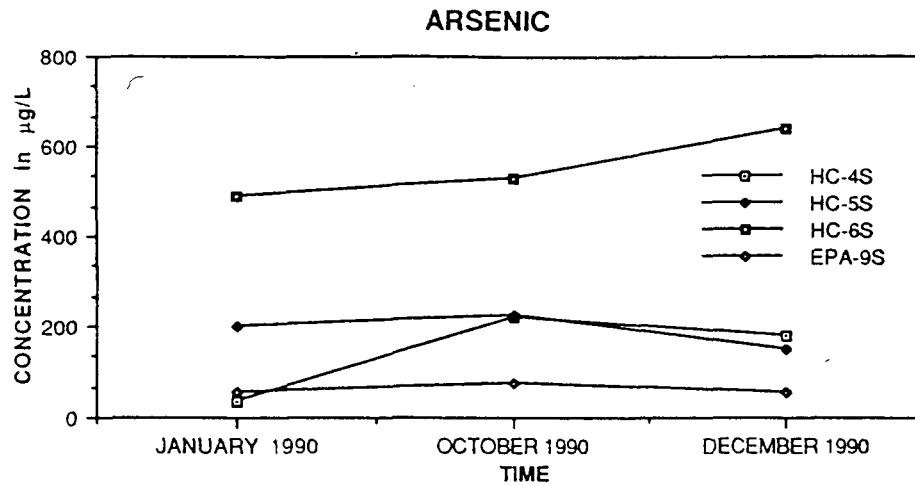


Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.

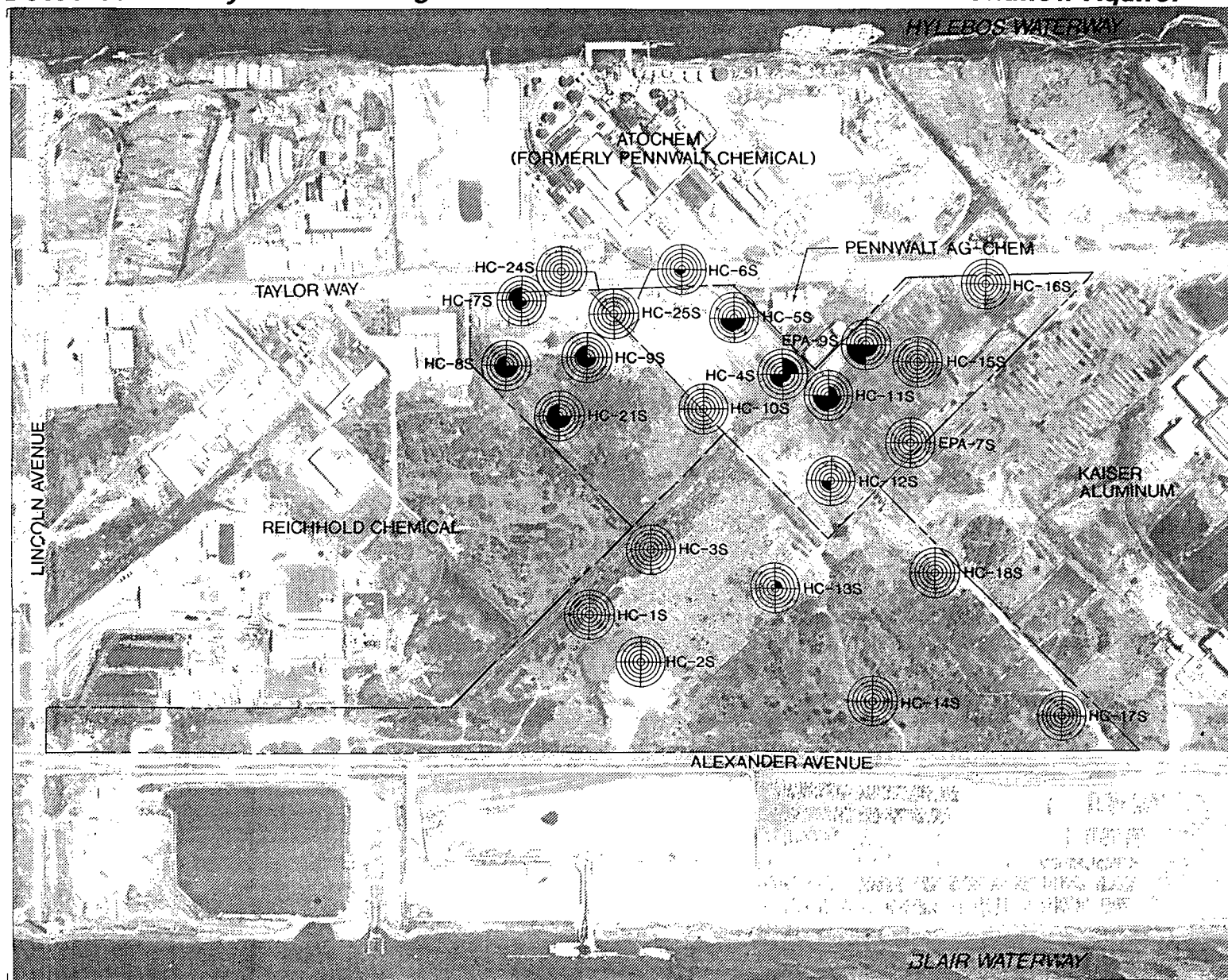


0 400 800
Approximate Scale in Feet

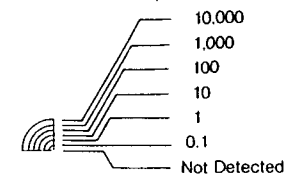
Concentrations of Selected Metals Over Time



Detected Priority Pollutant Organics Concentrations in Groundwater-Shallow Aquifer



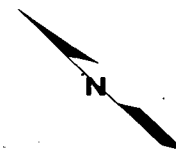
Concentration in $\mu\text{g/L}$ (ppb)



1. Vinyl Chloride
2. BTEX Compounds
3. cPAHs
4. Non-carcinogenic PAHs

December 1990 data were used to plot vinyl chloride and BTEX concentrations. Because detection limits for PAHs were significantly lower for the October 1990 data (using EPA method 8310) compared to the December 1990 data (using EPA Method 8270), we plotted the maximum detected concentration from these two data sets.

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.

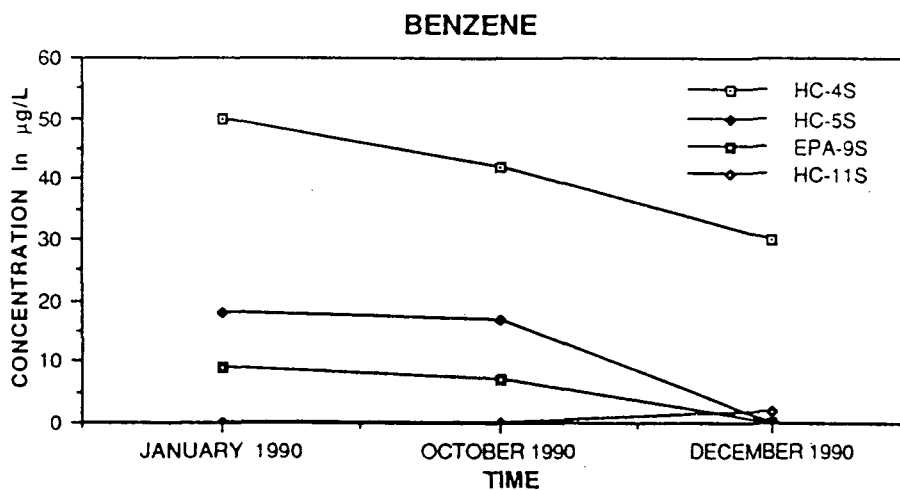
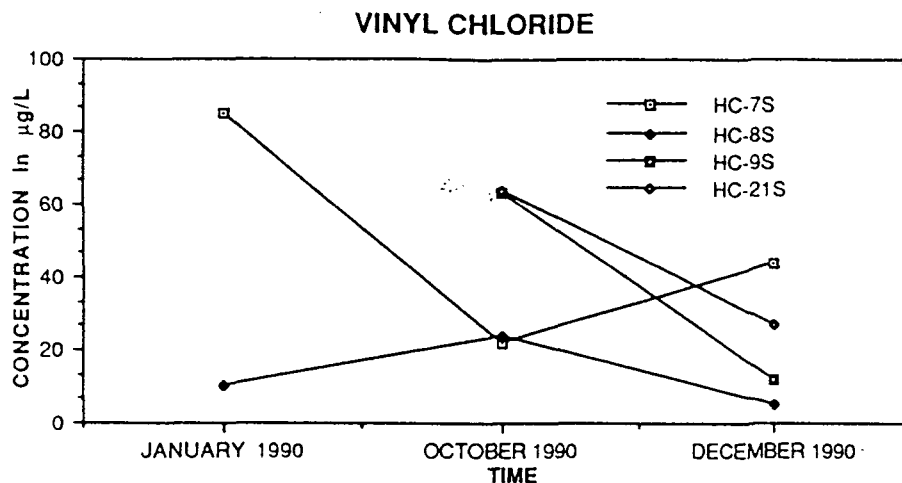


0 400 800
Approximate Scale in Feet



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Figure 25

Concentrations of Selected Volatile Organic Compounds Over Time

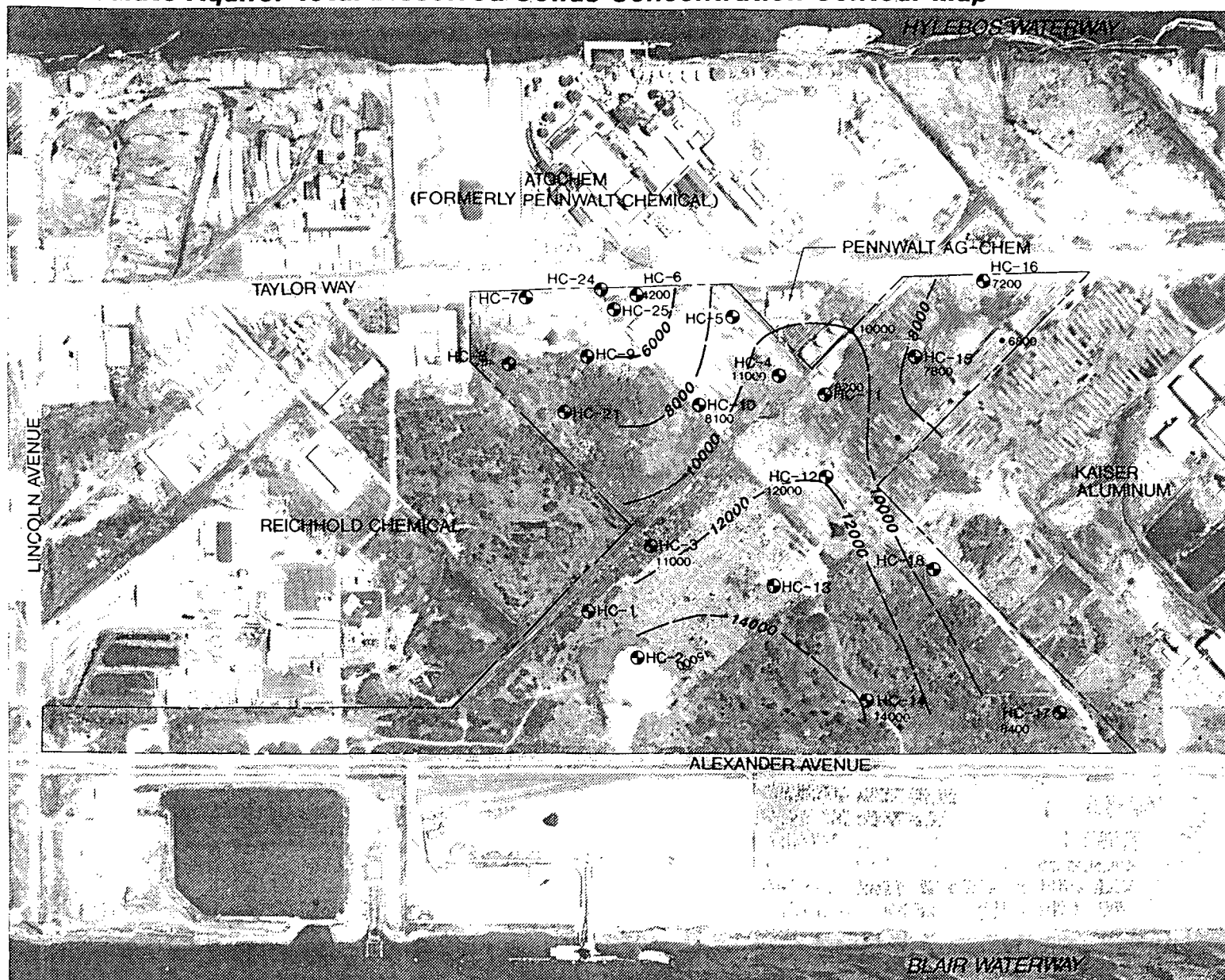


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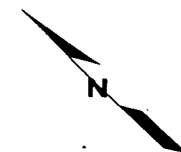
Figure 26

Intermediate Aquifer Total Dissolved Solids Concentration Contour Map



- HC-1 Hart Crowser Monitoring Well Location and Number
- 10000 TDS Concentration in ppm December 1990 Measurements
- 2000 TDS Concentration Contour in ppm
- Contour Interval=2000 ppm

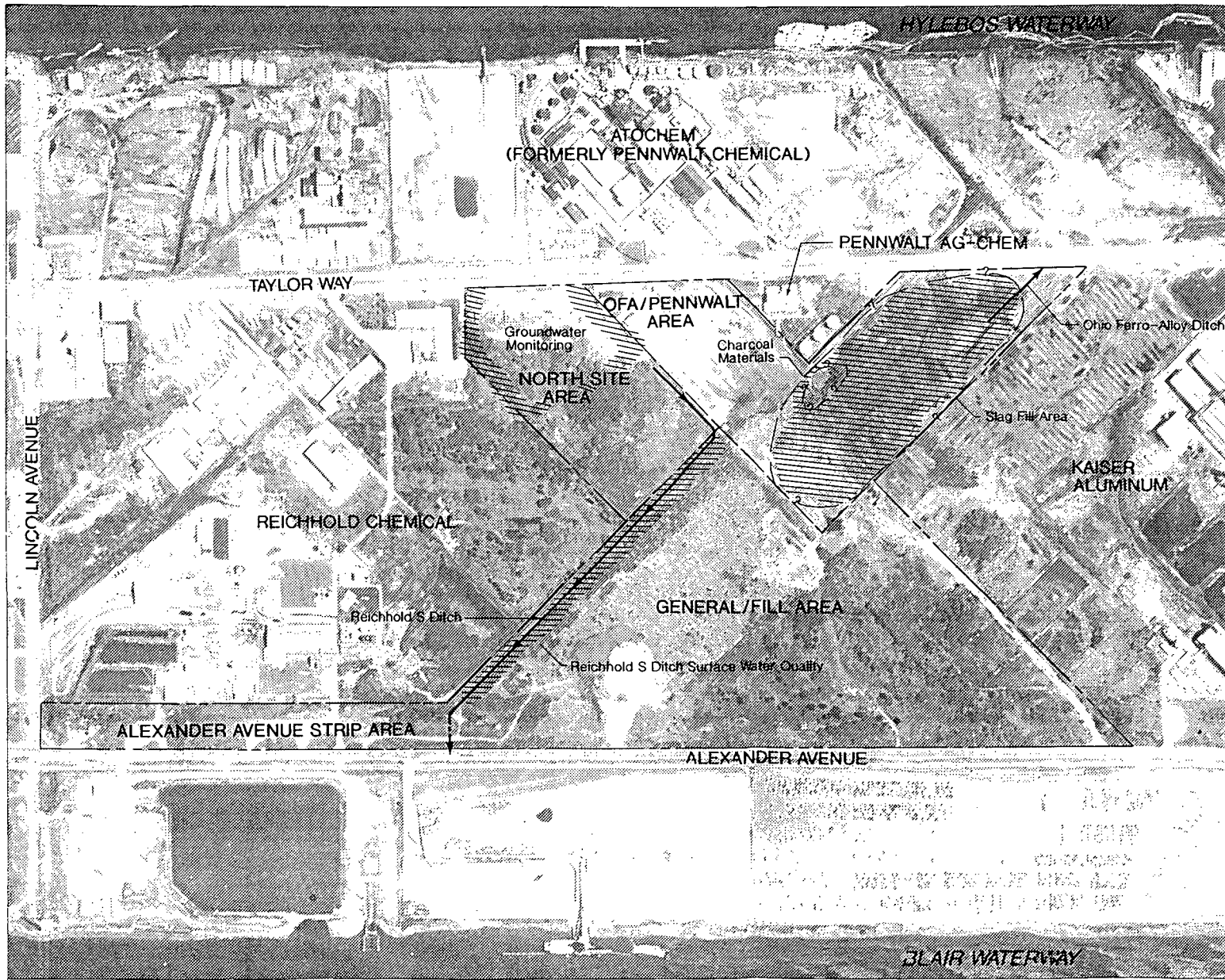
Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet

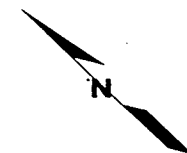
HART CROWSER
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Figure 27

Areas for Additional Action



Areas Identified for Additional Action

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet

HARTCROWSER
J-2350-07 10/91
Figure 28